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CONTRIBUTIONS FROM WALKER MUSEUM
VOLUME I. No. 7

NOTES ON SOME CARBONIFEROUS COCHLIODONTS, WITH DESCRIPTIONS OF SEVEN NEW SPECIES

BY
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NOTES ON SOME CARBONIFEROUS COCHLIODONTS WITH DESCRIPTIONS OF SEVEN NEW SPECIES

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The following article is the result of the writer's study of the teeth of the genera *Cochliodus*, *Psephodus*, *Sandalodus*, and *Deltodus*, in the collection of Walker Museum at the University of Chicago. In the collection are several hundred specimens of the teeth of *Sandalodus* and *Deltodus*, and more than fifty of *Cochliodus* and *Psephodus*.

The writer is under obligation to Dr. Stuart Weller for the privilege of studying the collection at Walker Museum, and to Professor C. E. McClung for the loan of specimens from the Kansas University Museum. Acknowledgment is due Professor S. W. Williston and Dr. Stuart Weller for helpful suggestions during the investigation.

Psephodus Agassiz

Cochliodus Agassiz, 1838 (*Recherches Poissons fossiles*, Vol. III, p. 174).
Cochliodus Portlock, 1843 (*Geological Report on Londonderry*, Plate XIV, Fig. 4).
Cochliodus McCoy, 1855 (*British Paleozoic Fossils*, p. 622).
Psephodus Agassiz, 1859 (MSS in the Enniskillen Collection).
Psephodus Morris and Roberts, 1862 (*Quarterly Journal of the Geological Society*, Vol. XVIII, p. 101).
Aspidodus Newberry and Worthen, 1866 (*Paleontology of Illinois*, Vol. II, p. 92).
Taeniodus St. John and Worthen, 1883 (*ibid.*, Vol. VII, p. 75).

A jaw of *Psephodus* with four teeth in place is preserved in Walker Museum at the University of Chicago. The full dentition of the jaw is probably not present, the front teeth having their anterior margins thick and truncated, as for articulation with other teeth. The missing anterior teeth were probably triangular in form and considerably smaller than those with which they articulate, but no place remains on the jaw for the helodoid teeth which have been so generally considered as forming a component part of the dentition of this genus.

The history of the belief in the association of helodoid teeth with the large plates on the jaw of *Psephodus* is interesting and is briefly sketched below.

The earliest mention of this supposed association is in a letter written by Captain Jones to Portlock, and published in 1843,[1] in which he says : "I think I am enabled to show that, however distinct and well marked the extremes may be, yet *Helodus planus* passes into *Cochliodus magnus*." In connection with this statement no evidence is given for its support. In publishing the results of his investigations on the arrangement of *Psephodus* teeth, Davis says in summary:

> That a row of three principal teeth increasing in size backward were attached to each cartilaginous ramus of the jaw; that the diameter of the jaw, as indicated by the groove or channel on the under surface of the teeth, diminished toward the symphysis; that a long narrow tooth was placed in front of the anterior one; and that a series of at least three helodoid teeth were placed behind it extending over the palate and increasing in size backward.[2]

The same year St. John and Worthen published the results of their studies on this genus and described an entirely different arrangement of the teeth. They conclude that—

> While the median portion of the rami of the jaw of *Psephodus* was enveloped by a moderately contorted dental plate, constituting its chief point of resemblance to *Cochliodus*, this plate was flanked on either side by a series of teeth disposed in rows from within outward similar to the occurrence of the teeth in the jaws of *Cestracion*. Therefore the solid triturating plates of *Psephodus* are not strictly homologous with the large posterior teeth of *Cochliodus*, but they are more properly designated as median teeth of the rami of the jaws [3]

In 1885 Traquair published his conclusions as to the arrangement of *Psephodus* teeth, saying:

> On the whole, I consider that view most likely to be correct which would ascribe to the mouth of *Psephodus* four large tooth plates, two above and two below, each occupying on the ramus a position similar to that of the row of the largest teeth of *Cestracion*, or of the so-called median teeth of *Cochliodus*, but that of the upper jaw differing slightly in form from the one opposed to it below. . . . . Teeth of different forms seem to have been present in the jaw, external to and in front of the large plate; those in its immediate vicinity belonging more or less to the category of *Helodus planus*. . . . . But the front of the jaw was armed

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[1] Portlock, *Geological Report on Londonderry* (1843), p. 462.

[2] *Scientific Transactions of the Royal Dublin Society*, Vol. I (1883), p. 417, Plate LV, Figs. 1–4.

[3] St. John and Worthen, *Paleontology of Illinois*, Vol. VII (1883), p. 64.

with small teeth belonging to the type which has been designated as *Lophodus* by Romanowski, and the forms *didymus* and *laevissimus*, both named as species of *Helodus* by Agassiz.[1]

During the progress of the present investigation a study of a portion of the types of *Psephodus crenulatus* and *P. obliquus*, in addition to the specimen already mentioned with the teeth in position, and described in this paper as *Psephodus legrandensis*, has led to the following conclusions: The teeth called median mandibular by St. John and Worthen[2] are posterior and correspond to the posterior teeth of *Cochliodus*. The teeth called median maxillary by the same authors are median, but not in the sense that they used the term. They articulate behind with the large posterior plates and in front with the small anterior teeth, and do not articulate with helodoid teeth, as St. John and Worthen thought. In this genus there is nothing that enables us to distinguish the maxillary from the mandibular teeth. Teeth like those called mandibular by St. John and Worthen have been found in place on the same jaw with those called maxillary. (See Plate I, Fig. 2.) All of the teeth of *Psephodus* that have been described belong in the categories hitherto known as median mandibular and median maxillary teeth, and, as before said, they occur on the same jaw.

In previous publications the commonly expressed opinion has been that helodoid teeth were present on the same jaw with the large grinding plates of *Psephodus*, although very little evidence in support of this has been forthcoming. The only evidence that seems to be of much weight in its support is that furnished by a specimen described by Traquair in 1885.[3] In this specimen forty-four helodoid teeth are preserved on the same slab with two of the large *Psephodus* teeth. It is no uncommon occurrence for teeth of different species to be preserved in close association, and the mere fact of such an association proves nothing, although, so long as no evidence to the contrary was forthcoming, it might well suggest the possibility that all the associated teeth belonged originally in the same jaw. Traquair's interpretation of the original position of these teeth in the jaw from their present positions on the slab shows that they are badly disarranged and might easily come from two or more specimens. He says[1] that of the two large teeth one belongs to the form called by Davis posterior, and the other to the form called median, but that they are not associated in such a way as to lend any support to that author's theory as to their arrangement. But the specimen of *P. legrandensis* furnishes positive evidence that Davis' theory in regard to the linear arrangement of the teeth is correct, with certain modifications. Only two large teeth are present in Traquair's specimen, while at least eight are necessary for the full dentition of both jaws. The teeth are so associated that Traquair concludes that the large plates occupied a position on the ramus similar to that of the median teeth of *Cochliodus*, and that helodoid teeth were arranged in front and external to them; but the specimen of *Psephodus legrandensis* before mentioned shows that such was not the position of the large plates, and that helodoid teeth could not have occupied the supposed place with reference to them.

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[1] Traquair, *Geological Magazine*, 1885, p. 343.

[2] *Paleontology of Illinois*, Vol. VII, Plate I, Figs. 1 and 2, pp. 66 and 67.

[3] *Geological Magazine*, 1885, pp. 337–44.

Although the linear arrangement of the teeth of *Psephodus* postulated by Davis is in part correct, the inner margins of the teeth are placed outward in his restoration, as has been pointed out by Traquair,[2] and a glance at the dentition of *P. legrandensis* (Plate I, Fig. 2) shows that there was no place on the jaw for helodoid teeth. On each ramus of the jaw one large posterior tooth, one median tooth, usually much smaller, but in some species nearly as large as the posterior tooth, and probably one small triangular anterior tooth, are present. But instead of the teeth being arranged in a semicircle, as Davis supposed, those of the two rami touch or approach each other very closely along the median line of the long axis of the jaw.

A comparison of the dentition of *Psephodus*, as shown in *P. legrandensis*, with that of *Cochliodus* brings out certain striking similarities. The arrangement of the large *Cochliodus* teeth is similar to that of *Psephodus*, the principal difference being that they do not meet along the median line, as in *Psephodus*, but spread apart, leaving a V-shaped area. The specimen from which Newberry and Worthen drew their conclusion that helodoid teeth were associated on the same jaw with *Cochliodus* teeth furnishes little evidence to support that hypothesis. The teeth are not in position, and they have the appearance of having been accidentally associated. Owen has shown[1] almost beyond question that *Cochliodus* had only three teeth on each ramus of the jaw, and more evidence than a few *Helodus* teeth found preserved in close association with *Cochliodus* teeth is necessary to demonstrate that they belonged in the same mouth. Thus it seems probable that in *Cochliodus* as well as in *Psephodus* no helodoid teeth were present in the dentition.

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[1] *Ibid.*, p. 342.

[2] *Ibid.*, p. 342.

Psephodus legrandensis *sp. nov.*

(Plate I, Fig. 2)

A small species. Median tooth 5^{mm} broad, 8^{mm} along inner margin, 5^{mm} along outer margin. Inner posterior angle acute and produced backward; outer posterior angle obtuse, rectangular on both sides in front. Tooth strongly enrolled transversely, not arched longitudinally. Inner margins of the two median teeth parallel to each other when in position on the jaw, and approaching very closely on the median line. Posterior teeth subpentagonal in outline, 11^{mm} from posterior inner angle to anterior angle of outer edge, 6^{mm} along articular edge in median line, 8^{mm} along articular edge for anterior tooth. Teeth strongly arched longitudinally, little arched transversely, not ridged or furrowed. Enamel everywhere finely punctate. Edges not crenulate.

The posterior teeth of this species are readily distinguished from *P. crenulatus*, *P. obliquus*, and *P. placenta* by their smaller size, comparative narrowness, and greater longitudinal arching. The median teeth are more strongly enrolled transversely and proportionately narrower than those of the species above mentioned. The median teeth are distinguished from those of *P. acutus* by their smaller size, greater enrollment and the posterior angle being much less produced.

Formation and locality: Kinderhook limestone; Legrand, Iowa.
Paleontological Collection, Walker Museum, No. 10038.

Psephodus acutus *sp. nov.*

(Plate I, Fig. 1)

Type and only specimen observed a median tooth. Measurements: 10^{mm} along the inner margin, 5^{mm} along the outer margin, 7^{mm} along the posterior articular edge, 6^{mm} along the anterior articular edge. Tooth not arched longitudinally, considerably enrolled transversely. Outer and inner margins parallel.

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[1] *Geological Magazine*, 1867, pp. 59–63.

P. acutus differs from *P. legrandensis* in the posterior inner angle being much more produced, in being less enrolled transversely, in its greater breadth, and in the anterior and inner margins meeting in a slightly more acute angle. The species is a little larger than *P. legrandensis*. The surface of the enamel is everywhere finely punctate.

Formation and locality: Coal Measures; LaSalle, Illinois.

Paleontological Collection, Walker Museum, No. 10036.

Psephodus carbonarius *sp. nov.*

(Plate I, Fig. 7)

Type and only specimen observed, a posterior tooth. Measurements: antero-lateral margin, 20^{mm}; postero-lateral margin, 18^{mm}; greatest breadth, 19^{mm}. Tooth thin, strongly arched transversely and longitudinally. Trapezoidal, with antero- and postero-lateral borders about the same length. Tooth highest near the anterior angle of the postero-lateral border. From this high point the surface declines abruptly to the anterior angle of the postero-lateral border and slopes down gradually to the other borders. Surface of enamel everywhere finely punctate. Lines of growth faintly impressed or absent. Margin not crenulate.

P. carbonarius is readily distinguished from *P. crenulatus* by being much more strongly arched and lacking crenulations.

Formation and locality: Coal Measures; Newport, Indiana.

Paleontologic Collection, Walker Museum, No. 10032.

Deltodus and **Sandalodus** Newberry and Worthen

That the genus *Sandalodus* has not been sufficiently well defined to separate it from *Deltodus* is shown by the disagreement among authors concerning the genus to which the species *Deltodus grandis* and *D. complanatus* should be assigned. Newberry, who described[1] both genera, says[2] that *D. grandis* is a typical *Deltodus*, while St. John and Worthen[3] and Eastman[4] believe that it is a *Sandalodus*. Newberry contends that *D. complanatus* is a typical *Deltodus*,[5] while St. John and Worthen[6] and Eastman[7] call it a *Sandalodus*.

During the progress of the present investigation several hundred specimens of the teeth of *Sandalodus* and *Deltodus* have been studied, and one fundamental difference, perhaps of family rank, seems to distinguish one genus from the other. This difference is in the number of teeth to each ramus of the jaw, *Sandalodus* having only one tooth to each ramus and *Deltodus* having three. Only the actual finding of the teeth in place can prove this conclusion beyond all question, but the evidence in hand makes it seem more than probable. In all cochliodonts, whose full dentition is known to have more than one tooth upon each ramus of the jaw, the posterior teeth have their antero-lateral margins modified for articulation with other teeth. The teeth of *Sandalodus* have no articular edge and show no sign of other teeth having been in contact with them. No teeth of proper shape and size to fit the large plates of *Sandalodus* have been observed during the present investigation. St. John and Worthen figure and describe[1] what they call median mandibular teeth of *Sandalodus laevissimus*, but, judging from the figures, the teeth are far too much enrolled to fit the large plates of *S. laevissimus*. Furthermore, if anterior teeth were present, they should be preserved in as great abundance as the so-called posterior teeth, but, aside from those figured by St. John and Worthen, none of the kind are known, while the posterior teeth are rather common. In the Burlington limestone, where the teeth of *Deltodus spatulatus* and *Sandalodus occidentalis* are about equally common, the anterior teeth of *D. spatulatus* are numerous, though usually fragmentary; but no teeth that fit the large plates of *S. occidentalis* have been found. In regard to the dentition of *Sandalodus*, Davis says: "It does not appear probable that there was more than one tooth to each ramus of the jaw."[2] Davis believes that the mandibular teeth of *Sandalodus* differ considerably from the maxillary teeth, but in a study of all the specimens of this genus in Walker Museum it has proved impossible to distinguish mandibular from maxillary teeth, and this is true also of *Deltodus*.

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[1] *Paleontology of Illinois*, Vol. II, pp. 95 and 102.

[2] *Transactions of the New York Academy of Science*, 1897, pp. 297 and 299.

[3] *Paleontology of Illinois*, Vol. VII, p. 184.

[4] *Bulletin of the Museum of Comparative Zoölogy*, Vol. XXXIX, p. 198.

[5] *Op. cit.*, p. 102. [6] *Op. cit.*, p. 184. [7] *Op. cit.*, p. 198.

There can be little doubt that *Deltodus* had three teeth on each ramus of the jaw. Owen has shown[3] that in the complete dentition

[1] *Op. cit.*, Vol. VII, p. 166, Plate XII, Figs. 8 and 9.

[2] *Scientific Transactions of Royal Dublin Society*, Vol. I (1883), Series III, p. 436.

[3] *Geological Magazine*, Vol. IV (1867), p. 60, Plates III and IV.

of the closely allied genus, *Cochliodus*, three teeth were present on each ramus, and it has already been shown in this paper that the same is true of *Psèphodus*. Davis figures one specimen of *Deltodus* dentition with two teeth in position on one ramus.[1] In discussing this specimen he says:[2]

> Connected with the posterior tooth a second one, hitherto regarded as a separate species under the name *Poecilodus parallelus*, has been found, which leaves no room to doubt that it is in its natural position, and from the character of its inside margin leads to the natural inference that a third tooth occupied the front or median portion of the lower jaw.

In all median teeth of *Deltodus* that are known the anterior edge is truncate or grooved, as if for articulation with other teeth.

Eastman says[3] that analogy of *Deltodus* with *Cochliodus*

> leads us to expect, in advance of the anterior dental plate, a series of helodus-like teeth above and below, and in front of this, at the symphysis of at least one jaw, a series of bilaterally symmetrical teeth, arched in a single plain, and corresponding to the form described by Newberry as *Helodus coxanus*.

No specimen of *Deltodus* furnishing any evidence in proof of this is known, and if, as it seems most probable, *Cochliodus* had no helodus-like teeth, there is nothing left to support such a hypothesis as to the dentition of *Deltodus*.

Sandalodus occidentalis Leidy

(Plate I, Figs. 8 and 9)

Cochliodus occidentalis Leidy, 1857 (*Transactions of the American Philosophical Society* (2), Vol. XI, p. 88, Plate V, Figs. 3–16).

Deltodus stellatus Newberry and Worthen, 1866 (*Paleontology of Illinois*. Vol. II, p. 97, Plate IX, Fig. 2 [not Fig. 3]).

Deltodus complanatus Newberry and Worthen, 1866 (*ibid.*, p. 98, Plate IX, Fig. 4).

Deltodus complanatus Newberry and Worthen, 1870 (*ibid.*, Vol. IV, Plate III, Figs. 5, 8, and 12).

Deltodus occidentalis St. John and Worthen, 1883 (*ibid.*, Vol. VII, p. 150, Plate IX, Fig. 9 [not Fig. 10]).

Deltodus intermedius St. John and Worthen, 1883 (*ibid.*, p. 153, Plate IX, Figs. 14 and 15).

Sandalodus complanatus St. John and Worthen, 1883 (*ibid.*, Vol. VII, p. 184, Plate XII, Figs. 1–4).

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[1] *Op. cit.*, Series II, Plate 52, Fig. 9.

[2] *Ibid.*, p. 430.

[3] *Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, p. 200.

Deltodus complanatus Newberry, 1897 (*Transactions of the New York Academy of Science*, Vol. XVI, p. 298, Plate XXIV, Figs. 1–7).

Deltodus occidentalis Eastman, 1903 (*Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, p. 200, Plate 4, Fig. 38, and Plate 5, Fig. 53).

Sandalodus complanatus Eastman, 1903 (*ibid.*, p. 198).

Teeth triangular in outline. In teeth of average size, 40–60^{mm} long, postero-lateral border about 1^{cm} longer than antero-lateral. The outer end terminates in an acute point; the inner end has the inner angle obtuse, the outer angle acute. Tooth slightly arched longitudinally and transversely, but, as compared with associated species, flat and thin. A low, broad ridge extends from the obtuse angle of the inner end to the outer end. From this ridge the surface declines very rapidly to the thin antero-lateral border and gently toward the postero-lateral border. Alation broad, slightly upturned. Enameled surface smooth and polished, everywhere finely punctate. Lines of growth usually not well marked. Antero-lateral border not modified for articulation with other teeth, usually straight or slightly convex.

S. occidentalis differs from *D. spatulatus* in being much less arched both longitudinally and transversely, and in having the ridge, which is not as high as in *D. spatulatus* extending from the obtuse angle to the outer end very close to the antero-lateral edge, instead of at some distance from it, as in *D. spatulatus.* The surface of the tooth declines rapidly to the antero-lateral border from the top of the ridge, and gently toward the postero-lateral border, while in *D. spatulatus* the stronger slope is toward the postero-lateral border. Antero-lateral margin not concave, as it is in *D. spatulatus.*

This species is referred to *Sandalodus* because there is evidently only one tooth to each ramus of the jaw. As has been stated, the large teeth have no articular edge, and although they are numerous in the Burlington limestone, no teeth have been found that could occupy the position of the median or anterior teeth as present in the dentition of *Deltodus*, *Cochliodus*, and *Psephodus.*

In examining a large number of fragmentary teeth of *Sandalodus complanatus* and *Deltodus occidentalis*, it was found impossible to distinguish one species from the other, and, after examining more than a hundred well-preserved teeth, the conclusion was reached that the two groups of teeth represented a single species. In large collections they grade into each other to such an extent that it is impossible to separate them, but it is not difficult to understand how they came to be described as two distinct species from scanty material.

Eastman says[1] he is convinced that "the teeth figured as *Deltodus complanatus* in the posthumous paper of Newberry are fragments of *D. occidentalis*." These specimens are now preserved in the collection of Walker Museum, and as two of them are practically complete, there is no reason why Newberry should have identified them incorrectly, and with the union of the two species both Newberry and Eastman are correct in their conclusions.

Formation and locality: Kinderhook, Burlington, and Keokuk limestones; Iowa, Illinois, and Indiana.

Sandalodus emarginatus *sp. nov.*

(Plate II, Figs. 1, 2 and 3)

A very large species. The dimensions of the type specimen are: 95^{mm} along the antero-lateral border, 65^{mm} along the inner end, 110^{mm} along the postero-lateral border, 26^{mm} in thickness at the thickest part. Strongly arched longitudinally and transversely. Alation strong, extending out 40^{mm} from the postero-lateral border. At the place where this alation diverges from the main part of the tooth there is a strong notch which extends to the middle of the alation in a line parallel with the main axis of the tooth. The anterior border of the alation is gently convex to near the outer angle, where it is strongly convex. The alation is thick and strong, does not turn up at the outer angle, and has a sharp ridge extending from the outer angle to the middle of its base, the sharpness of this ridge being due to the worn condition of the tooth near the inner border. Lines of growth show faintly on this worn surface. Inner end of tooth gently convex near the antero-lateral border, gently concave near the postero-lateral border. Inner posterior angle slightly obtuse. Outer end curved abruptly downward, and probably wound once and a half on itself as in *Sandalodus laevissimus*.

S. emarginatus differs from *S. laevissimus* in being more strongly arched both transversely and longitudinally, in being thicker and stronger, in having a strong notch where the alation diverges from the main part of the tooth, and in the alation being thick, convex upward, and not turning up at the point:

The types of *S. emarginatus* are two specimens, one of which is almost perfect, only a small part of the initial coil being absent; the other has lost part of the initial coil and half of the alation.

Formation and locality: Keokuk limestone; Keokuk, Iowa.

Paleontological Collection, Walker Museum, No. 10059.

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[1] *Op. cit.*, 1903, p. 198.

Sandalodus alatus Newberry and Worthen

(Plate I, Figs. 3-5)

Deltodus alatus Newberry and Worthen, 1870 (*Paleontology of Illinois*, Vol. IV, Plate II, Fig. 6, p. 368).

Deltodus alatus Woodward, 1889 (*Catalogue of Fossil Fishes in British Museum* Part I, p. 199).

Deltodus spatulatus Eastman, 1903 (*Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, p. 198).

In a paper published in 1903 (*loc. cit.*, p. 198) Eastman gives *Deltodus alatus* as a synonym of *D. spatulatus*. The specimens of *D. alatus* teeth in the collection of Walker Museum are all more or less fragmentary, but they present the following characters which serve to distinguish them from *D. spatulatus*. The pores in the enamel are much larger and fewer in number. The average number per square millimeter being four in *D. alatus* and seven in *S. spatulatus*. The postero-lateral border of *D. alatus* teeth has a broad, thin alation extending its full length. Near the outer end this alation is much broader than the accompanying ridge. In the posterior teeth of *D. spatulatus* the alation is not broad, but it is thick, and it disappears near the outer end. *D. alatus* teeth have a thin, narrow alation along the antero-lateral border, while the antero-lateral border of *D. spatulatus* teeth is thick, has no alation, and is modified for the attachment of other teeth.

This species is referred to *Sandalodus* because it seems to have but a single tooth to each ramus of the jaw.

Formation and locality: Keokuk and Burlington limestones; Iowa and Illinois.

Sandalodus porcatus *sp. nov.*

(Plate I, Fig. 14)

Type a single incomplete tooth. Length along antero-lateral edge, 34^{mm}; breadth above alation, 14^{mm}; greatest thickness, 10^{mm}. As the outer part of the alation is missing, its full dimensions cannot be ascertained. Tooth very thick and strong at the inner end, but becoming thin along the antero-lateral border near the outer end. The postero-lateral border is thick from the outer end to the alation, but becomes quite thin along the margin of the alation. The alation resembles that of *S. emarginatus* in being convex upward and very thick and strong. It occupies considerably more than half the postero-lateral border of the tooth, and diverges from this border at an angle a little greater than 100°. Tooth strongly arched longitudinally and transversely, excepting at the outer end, where the transverse arching is much less than in *S. laevissimus* and *S.*

emarginatus. The transverse arching near the inner end is much stronger than in any other species of *Sandalodas*. The outer end was probably enrolled as much as in *S. laevissimus*, but the enrolment is partially broken away. Enamel punctation so fine that it can with difficulty be detected with the naked eye. The tooth is peculiar in having a sharp ridge along the higher part running from the outer end to the inner. From the antero-lateral border six small ridges with sharp crests pass upward and forward, joining the large ridge at the top. The posterior one of these ridges is quite strong, but they decrease in size progressively toward the anterior end of the tooth, and the anterior one is very faintly marked. No lines of growth are present.

This species differs from *S. emarginatus* in the presence of the ridges above mentioned, in its greater transverse arching near the inner end and lesser transverse arching near the outer end, in the relative width of the alation, in the fineness of the enamel punctation, and in its size.

Formation and locality: St. Louis limestone; Salem, Ind.

Paleontological Collection, Walker Museum, No. 10050.

Sandalodus latidens *sp. nov.*

(Plate I, Fig. 11)

Teeth of medium size, comparatively broad, not arched longitudinally, little arched transversely. Pointed at the anterior end. The antero-lateral margin forming a strong curve, the postero-lateral margin straight for 12^{mm} from the outer border, then diverging to form a prominent shoulder, rounded at the outer part. This shoulder extends out 8^{mm}, and from its point the postero-lateral margin passes backward in a straight line, converging slightly toward the main axis of the tooth, until it approaches the posterior border, where it curves inward and meets the antero-lateral border in the line of the main axis. Surface of enamel coarsely punctate. Lines of growth showing as delicate color markings, with no ridges present. Greatest length of tooth, 48^{mm}; greatest breadth, 27^{mm}.

The breadth, shape, and punctation of this tooth are probably of generic value, but it is here placed provisionally with *Sandalodus*, as there can be little doubt that there was only one tooth to each ramus of the jaw.

Formation and locality: Keokuk limestone; Keokuk, Iowa.

Paleontological Collection, Walker Museum, No. 10035.

Deltodus spatulatus Newberry and Worthen

(Plate I, Figs. 10, 12, and 13)

Deltodus spatulatus Newberry and Worthen, 1866 (*Paleontology of Illinois*, Vol. II, p. 100, Plate IV, Fig. 7).

Deltodus spatulatus Newberry and Worthen, 1870 (*ibid.*, Vol. IV, Plate III, Fig. 11).

Cochliodus costatus (*pars*) Newberry and Worthen, 1870 (*ibid.*, p. 364, Plate III, Fig. 12 [not Fig. 10]).

Deltodus spatulatus Newberry, 1879 (*Annual Report of the Geological Survey of Indiana*, p. 346).

Deltodopsis? convolutus St. John and Worthen, 1883 (*Paleontology of Illinois*, Vol. VII, p. 165, Plate XI, Figs. 11 and 12).

Cochliodus costatus (*pars*) St. John and Worthen (*ibid.*, p. 167).

Deltodus latior St. John and Worthen (*ibid.*, p. 145, Plate IX, Figs. 11 and 12).

Deltodus spatulatus Newberry, 1897 (*Transactions of the New York Academy of Science*, Vol. XVI, p. 292, Plate XXIX, Figs. 8–11).

Deltodus spatulatus Eastman, 1903 (*Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, Plate IV, Figs. 41 and 42; Plate V, Fig. 55).

In the collection of Walker Museum are several nearly perfect specimens of *Deltodus spatulatus* teeth from the Keokuk limestone, and a large number of more or less complete specimens from the Burlington limestone. Those from the Keokuk are generally much better preserved than the ones from the Burlington. On the Keokuk specimens a few lines of growth are usually present, but the Burlington specimens rarely have lines of growth developed. One specimen from the Keokuk is remarkable for the great development of the outer end of the tooth. It curves downward and backward, lacking about 100° of forming a complete circle. From the fact that this curved part is very slender, and consequently would rarely be preserved, it is possible that it was generally developed to a much greater degree than has formerly been supposed. The complete outer end or antero-lateral margin has not been observed in any of the teeth from the Burlington limestone.

A study of these specimens substantiates Eastman's view[1] that *Deltodopsis? convolutus*[2], and the narrow, strongly enrolled teeth called by Newberry and Worthen *Cochliodus costatus*[3] are probably the median or anterior teeth of *Deltodus spatulatus*. A great many teeth of this character have been found in the Burlington limestone. They are usually fragmentary, but fit the posterior teeth of *D. spatulatus*, and there are no other posterior teeth from that formation with which they can be classed.

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[1] *Bulletin of the Museum of Comparative Zoölogy at Harvard College*, Vol. XXXIX, p. 199.

[2] St. John and Worthen, *Paleontology of Illinois*, Vol. VII, p. 165, Plate XI, Figs 11 and 12.

[3] *Ibid.*, Vol. II, p. 364, Plate III, Fig. 12? (not. Fig. 10).

Formation and locality: Kinderhook, Burlington, and Keokuk limestones; Illinois, Iowa, and Indiana. Numerous in the Burlington and rare in the Kinderhook.

Deltodus attenuatus *sp. nov.*

(Plate I, Fig. 6)

Tooth triangular in outline. The type specimen measures 22^{mm} along the antero-lateral border, 27^{mm} along the postero-lateral border; inner margin, 15^{mm}. Tooth slightly arched longitudinally, little arched transversely. A ridge runs from the acute angle of the posterior border to the anterior border. The tooth slopes down abruptly from this ridge to the postero-lateral border, excepting at the posterior angle, where there is an alation that turns upward. The postero-lateral border is very thin. Toward the anterior border there is no depression, the rest of the tooth being the same height as the ridge. The antero-lateral margin is very thick at the inner end, but thins out toward the outer end. The posterior inner angle is obtuse, the posterior outer angle acute. The surface of the enamel is very finely punctate throughout.

This species differs from *Deltodus angularis* (*Orthopleurodus carbonarius*) St. J. and W. in being much narrower and thinner, much less arched both longitudinally and transversely, and in the character of the ridge.

The type specimen, a posterior tooth from left mandible or right maxilla, is from the Coal Measures near Kansas City, Mo. It is now in the collection of the University of Kansas.

PLATE I

FIG. 1.—*Psephodus acutus* sp. nov. Median tooth of left mandible or right maxillary.

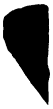
FIG. 2.—*Psephodus legrandensis* sp. nov. Dentition of one jaw; anterior teeth restored in outline.

FIGS. 3–5.—*Sandalodus alatus* N. and W. Fig. 4 shows the alations on both sides of the tooth. Fig. 3 has the alations restored in outline. Fig. 5 shows the characteristic punctation of the teeth.

FIG. 6.—*Deltodus attenuatus* sp. nov. Posterior tooth; anterior end and part of alation restored.

FIG. 7.—*Psephodus carbonarius* sp. nov. An almost perfect posterior tooth.

FIGS. 8 AND 9.—*Sandalodus occidentalis* Leidy. Fig. 8 shows the characteristic shape of the anterior edge of the teeth of this species. Fig. 9 shows posterior end of tooth; anterior end restored from more perfect specimens.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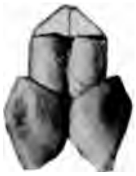
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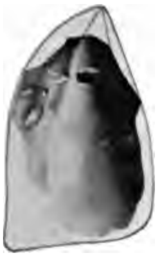
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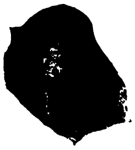
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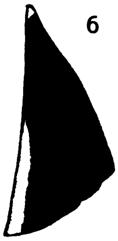
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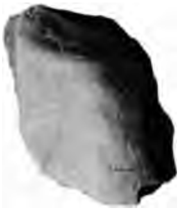
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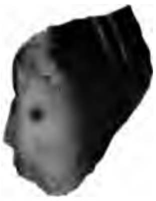
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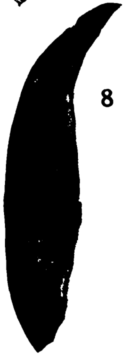
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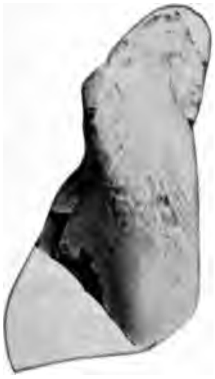
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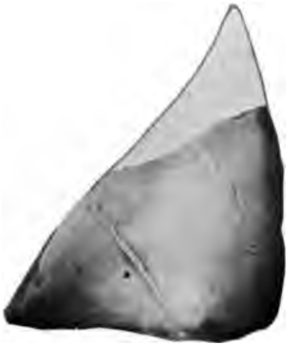
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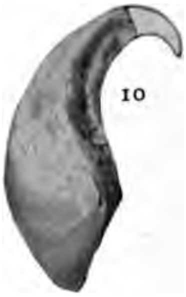
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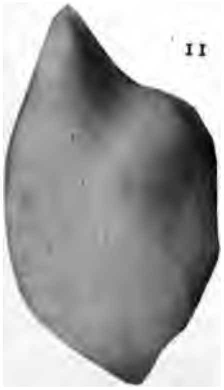
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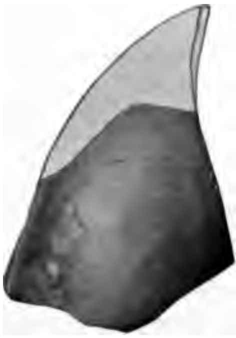
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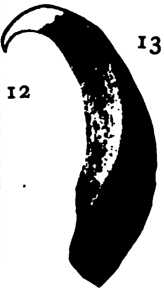
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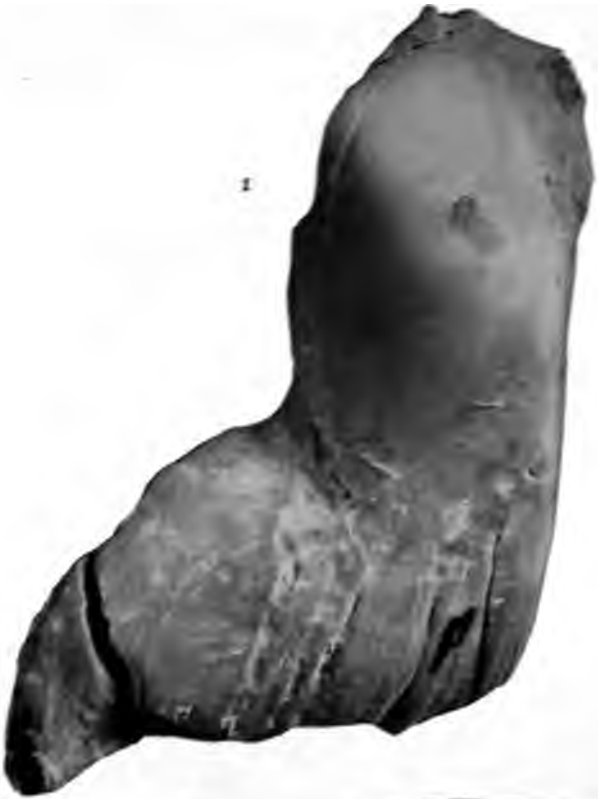
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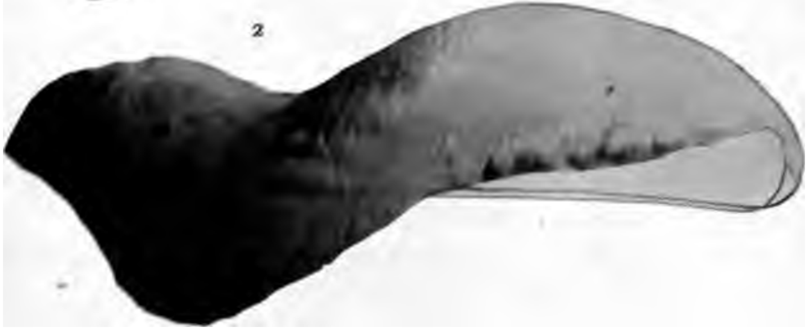
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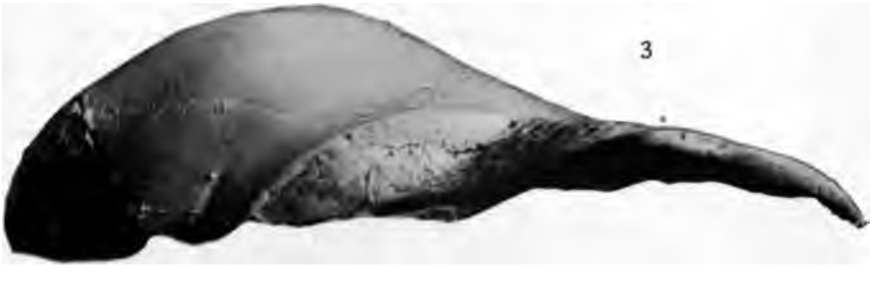
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FIG. 11.—*Sandalodus latidens* sp. nov. A perfect tooth.

FIGS. 10, 12, AND 13.—*Deltodus spatulatus* N. and W. Figs. 10 and 13 show the characteristic shape of antero-lateral edge of the teeth of this species; anterior end restored. Fig. 12 shows the shape of the posterior end of the teeth of this species, anterior end restored.

FIG. 14.—*Sandalodus porcatus* sp. nov. Tooth with part of anterior end and alation restored.

PLATE II

FIGS. 1–3.—*Sandalodus emarginatus* sp. nov. Fig. 1, top view of complete tooth. Fig. 2, antero-lateral edge of same tooth; outline to show relation of postero-lateral edge. Fig. 3, postero-lateral edge of same tooth.

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Volume I. No. 9

(1) The Osteology of Some American Permian Vertebrates. II

(2) Synopsis of the American Permocarboniferous Tetrapoda

BY
SAMUEL WENDELL WILLISTON

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THE OSTEOLOGY OF SOME AMERICAN PERMIAN VERTEBRATES. II

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University of Chicago

PANTYLUS

There is no genus of Cotylosauria of more interest at the present time than that described many years ago by the late Professor Cope as *Pantylus*,[1] from the Permian of Texas.

The genus originally was based upon an imperfect skull, and other specimens were unknown until a few years ago, when another skull, but little better than the type, was discovered by Mr. Paul Miller and described by Mr. M. G. Mehl. On the basis of the known material, Dr. Case in 1911 founded the suborder Pantylosauria. Aside from the skull, not a fragment of the skeleton has hitherto been recognized. Within the past two years, Mr. Miller has found parts of not less than seven additional skeletons and skulls which add not a little to our knowledge of the genus. All these specimens come from a single horizon, a nodular layer, which has also yielded the type specimens of *Broiliellus*, *Glaucosaurus*, and *Mycterosaurus*, numerous specimens of *Captorhinus*, and the specimen of *Theropleura* described in the following pages. Only one specimen, probably belonging in this genus—that described by me as *Ostodolepis*—may be from a different horizon, on Coffee Creek.

The skull (Figs. 20–27).—The material studied comprises three nearly complete skulls, and parts of five others. The most perfect of these, as also the largest, the one figured (Figs. 20, 21), lacks the right posterior part only. This specimen, like most of the others, was preserved in a light-colored, argillaceous nodule, and, as usual in such nodules, has suffered very little from compression or distortion; unfortunately in such specimens the sutures are traceable with difficulty. Certain ones of the left side are conspicuous, but others are concealed beneath a sort of glaze. A second, very complete specimen (Fig. 26) is that of a very young animal, or possibly of a distinct species, not one-third the linear dimensions of the others. The mandibles are in position and the palate is shown only in part. Some of the sutures are very clear, others are doubtful. The skull is flattened and somewhat distorted. A third, nearly complete skull has the mandibles in position, but is compressed and distorted; it was not preserved in a clay nodule; only a few sutures are discernible. Of the other specimens, all found together, there are parts of four skulls, several series of connected vertebrae, with parts of the pectoral girdles and fragments of limb bones. One of the skulls is represented by

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[1] Cope, *Bull. U.S. Geol. Surv. Terr.*, VI (1881), 79; *Trans. Amer. Phil. Soc.* (1892), p. 14; *ibid.* (1896), p. 450; Case, *Revision of the Cotylosauria of North America* (1911), pp. 59, 113; Mehl, *Jour. Geol.*, XX (1911), 21; Huene, *Bull. Amer. Mus. Nat. Hist.*, XXXII (1913), 354; Broom, *Bull. Amer. Mus. Nat. Hist.*, XXXII (1913), 527.

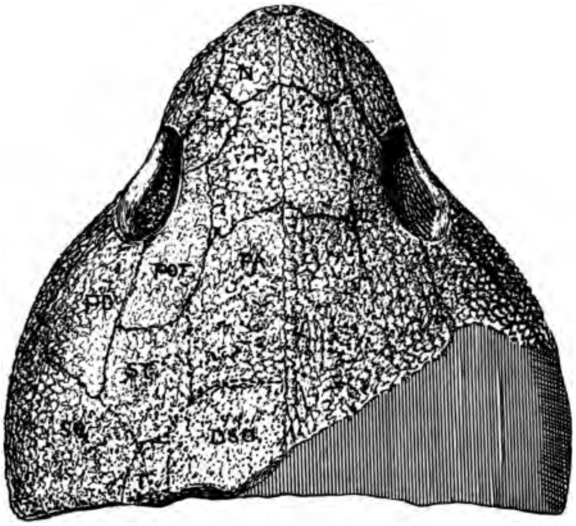

FIG. 20.—*Pantylus:* Skull, from above. Three-fourths natural size. For explanations see below.* No. 269.

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* Explanations of the skull elements of all figures: ***ang***, angular; *art*, articular; *bo*, basioccipital; *c*, ***cor***, coronoid; *d*, dentary; *dso*, dermosupraoccipital; *eo*, exoccipital; *fr*, frontal; ***hyp***, hypophysis; *it*, intertemporal; *l*, lacrimal; ***m***, maxilla; ***n***, nasal; ***oc***, occipital condyle; *pa*, parietal; *pal*, palatine; *pf*, *p*, prefrontal; *pfr*, postfrontal; ***pm***, premaxilla; *po*, postorbital; *ps*, parasphenoid; *psp*, postsplenial; *pt*, pterygoid; *q*, quadrate; *qj*, quadratojugal; *sa*, surangular; *so*, supraoccipital; *sp*, splenial; *st*, supratemporal, stapes; *sta*, stapes; *sq*, squamosal; *t*, tabular; *v*. prevomer.

the anterior part, the others by cleanly broken fragments of the posterior part. In addition I have studied the specimen previously described by Dr. Mehl.

The chief features determined from all these specimens I have endeavored to show in the illustrations, which, I trust, will render detailed descriptions unnecessary. I give only such characters as are revealed by these specimens, that is, I have not drawn upon any previously published figures or descriptions.

That there are more than one species among these specimens is not improbable, but if so the material is too imperfect to differentiate them, and our present concern is not with specific characters. Such sutures as are given in continuous lines have been corroborated by more than one specimen, and may be accepted as proved. Others which seem probable, but which lack definite corroboration, are shown in dotted lines. Of interest are the extent and position of the sutures on the inner and outer cranial tables, as shown partly in Fig. 23. Those of the inner side, as shown by continuous lines, are quite alike in two specimens, in which the bone had been very cleanly separated, leaving its perfect mold, upon which the sutures are clearly indicated. It will be observed that the quadratojugal extends far up on the side internally, broadly covered by the squamosal. Externally the squamosal, as shown by the broken lines, extends to the lower end of the quadrate, leaving the very narrow extremity of the quadratojugal between it and the cotylar surface of the surangular. One specimen, from which the squamosal had been removed, shows the

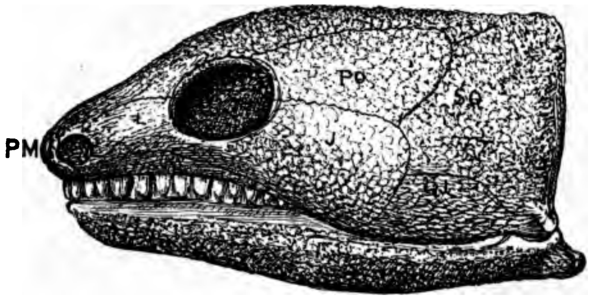

FIG. 21.—*Pantylus:* Skull, from side. Three-fourths natural size. No. 269

quadratojugal bordering the quadrate throughout nearly its whole extent beneath the squamosal. The squamosal turns inward to cover nearly all the posterior surface of the quadrate, except its inner border. Above, on the posterior side, another bone, doubtless the tabular, covers the upper end, as shown by impressions, but its limits cannot be determined.

The quadrate is nearly wholly covered posteriorly by the thin overlap of the squamosal (Fig. 24). At the extreme lower end, only, the condyle is exposed from behind, above the articular, and on the inner side there is a narrow space of the pterygoid wing of the quadrate visible along its whole length. The extreme end of the quadratojugal enters slightly into the articular surface for the mandible. A sutural line on the impression shows that the pterygoid wing of the quadrate is narrow and thin.

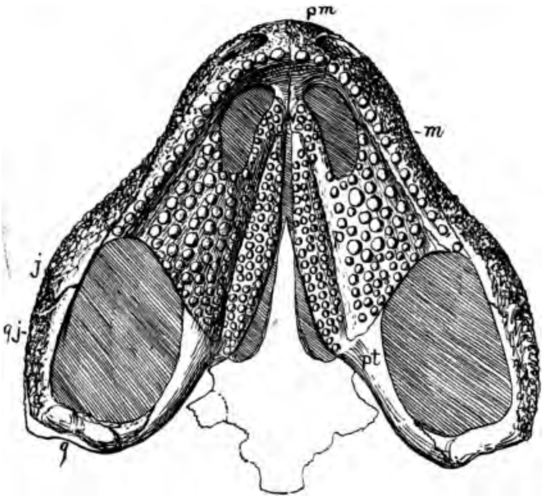

FIG. 22.—*Pantylus:* Cranium, from below. Three-fourths natural size. No. 1069

There are fifteen or sixteen teeth on each maxilla and two on each premaxilla. They are, for the most part, rather obtuse, but those of some of the smaller skulls are more acute.

The *palate*, as figured (Fig. 22), is shown very perfectly in one of the specimens, one preserved without the mandibles, from which the matrix has been nearly wholly removed. The prevomers are short bones, articulating anteriorly with small and short premaxillary processes. Their connection posteriorly cannot be determined precisely. The pterygoids extend far forward as narrow bones; they are clearly differentiated in two specimens. Anteriorly they join the prevomers on their inner side obliquely, and the anterior extremity of the parasphenoidal prolongation above, as figured (Fig. 25, *F*). They bear about three rows of small teeth, which extend backward as far as the basipterygoid processes. On each pterygoid there are about fifty teeth.

The basipterygoid processes are rounded projections which meet the downwardly turned processes (Fig. 25, *B*) of the basisphenoid in a free joint. Back of these the pterygoids are directed outwardly, gradually becoming broader till they reach nearly to the skull roof and the whole height of the quadrate (Fig. 24, *pt*). I can find no evidence in any specimen of an epipterygoid, though there may have been such a bone.

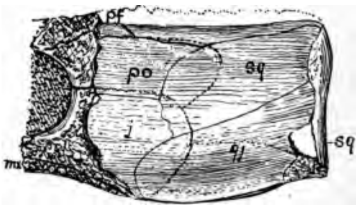

FIG. 23.—*Pantylus:* Left temporal region of skull, from without. Three-fourths natural size.

The internal nares are very large, as shown in the figure (Fig. 22), bounded internally by the vomers, posteriorly and posteroexternally by the palatines, anteriorly and anteroexternally by the maxillae and premaxillae. The palatines are very large and thick bones (Fig. 22, *p*), slightly convex below, and covered throughout by teeth, which, in shape and size, are nearly like those of the mandibles. There is no large tooth corresponding to that of the coronoids in this specimen, though the outer teeth are larger than the inner ones. Behind, the suture separating the palatine from the pterygoid is clearly shown. In one specimen, in which the upper side of the massive palatine plate is exposed, two lines are visible posteriorly bounding a slender process of the pterygoid, which extends outward to the jugal. I do not doubt that they are sutures, though, as they cannot be corroborated, their identification is in a measure provisional There are no evidences of a separate ectopterygoid. It is a rather remarkable fact that, so far, in no specimen of an American Permian reptile has there been presented indubitable proof of a separate ectopterygoid. It has been reported in *Diadectes*, but in two excellent specimens of this genus in the Chicago collections I can find no evidences of it.

In the juvenile specimen (Fig. 26) mentioned the undersurface between the mandibles and posteriorly is shown nearly completely. A broad parasphenoid extends far forward between the pterygoids filling the interpterygoid space. The basisphenoid is smooth and shallowly concave, without definite basisphenoid processes.

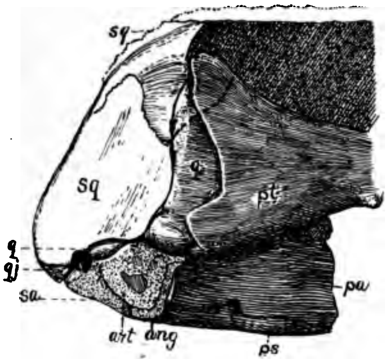

FIG. 24.—*Pantylus:* Left quadrate region of skull, with section of mandible through condyle. Enlarged . one-half.

In one specimen, most of the bones of the brain-case have been preserved in the matrix, but separated from each other. Some of these have been cleared of their investing matrix to show their shapes. In Fig. 25, *B* is shown the underside of the basisphenoid to the parasphenoid process. The parasphenoid is broken just in front of the basipterygoid processes; its section is shown in Fig. 25, *C*.

Lying to one side and a little above the basisphenoid is the anterior part of the basioccipital (Fig. 25, *A*); its posterior part is lost. Its front part is thin where it joined with the basisphenoid; posteriorly it is thickened. In addition to these two bones and overlying them there is a thin bone of doubtful identity. It has the shape of an acute V in section, its lower border thin and sharp.

On each side of the parasphenoid, as shown in the figure (Fig. 25), a thin plate of bone extends to the skull roof, beginning opposite the basipterygoid processes. In life they were nearly parallel, but one is broken and bent in the specimen. A little farther forward, about opposite the hind margins of the orbits, these plates curve strongly outward near their middle but unite in the median line above (Fig. 25, *D*). At the extreme front end of the parietal, as shown in the outline figure (Fig. 25, *E*), the chamber is much contracted in its greatest width, but thenceforward it expands widely in its roof attachments, filling nearly the whole of the roof space between the orbits below the cranial roof. Its lateral front ends connect with the thickened roof above the angle of the lacrimal (Fig. 25, *F*). The sphenoid, from which these lateral walls arise, terminates in front above the pterygoids and vomers.

The structure of this region seems to be quite like that of *Diadectes* and like that of the temnospondyl amphibians.

Mandibles (Fig. 27).—The material studied comprises parts or wholes of ten mandibles, five of them attached to crania and in consequence only permitting some of the details of the exterior to be seen. Two isolated mandibles and a part of a third have furnished most of the described characters. In addition there are sections of two others of those attached to the skulls. Two of these specimens, the one studied by Mehl, and the posterior half of another connected with a cranium, are of large size, and differ in the absence of the large median coronoid tooth conspicuous in the others; they may indicate a distinct species. Nearly all the sutures have been corroborated throughout in from one to five specimens. The suture separating the splenial from the postsplenial agrees in four specimens. The sections shown in the figures are from specimens other than those represented by the nearly complete figures.

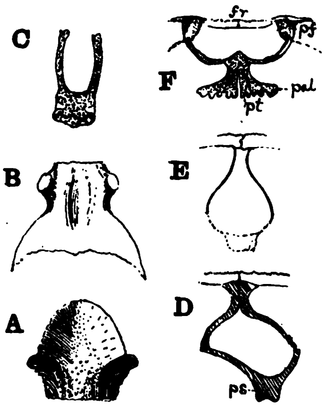

FIG. 25.—*Pantylus:* Internal cranial bones. Natural size. *A*, basioccipital; *B*, basisphenoid; *C*, section at front of basisphenoid; *D*, section of rhinencephalic chamber opposite hind margin of orbits; *E*, outline of same at extreme front end of parietals; *F*, same in front of orbits; *pal*, prevomer.

The figures will, I trust, render unnecessary a detailed description of the different elements. The two splenial bones, recognized for the first time in an air-breathing vertebrate in 1913, are here for the first time recognized in a reptile. Their discovery was to be expected, since no other constant differences have yet been found between reptiles and amphibians. That the coronoid of *Pantylus* is really composed of more than one element is not improbable, but the proof will be difficult, since the teeth are so closely placed that the distinguishing sutures will not be easily recognized, even where the matrix is absent.

Lying within the meckelian cavity there is a thin, flat plate or bone sheathing more or less the inner side of the dentary, and extending at least as far forward as the splenial. Unless it be a distinct, unnamed element, which is not probable, it must be the continuation of the surangular; and this seems most probable. A similar bone in a like position is characteristic of most specimens of amphibian mandibles which I have sectioned.

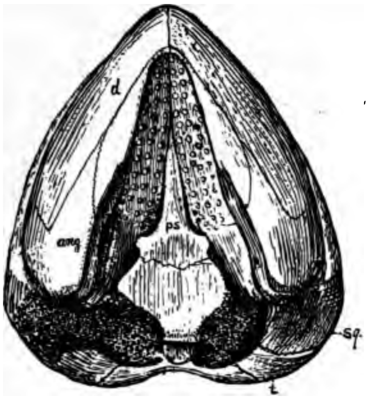

FIG. 26.—*Pantylus:* Skull of immature animal, from below. Natural size. No. 1071.

The suture between the angular and surangular it is seen (Fig. 24, *art*, *sa*) passes through the cotylar surface, the outer part of the articular surface being formed by the surangular, as in the mosasaurs. This position of the suture probably explains the failure hitherto to distinguish the limits of the articular in the amphibians.

The identity of the real splenial seems open to doubt. I have given reasons for my belief that it is the anterior of the two bones which is homologous with the splenial of modern reptiles. I am now inclined to the opinion that it is the posterior of the two—my so-called postsplenial—which has persisted, and that it is the anterior one which has disappeared. It will be observed that the posterior bone occupies the position and has the relations of the true splenial in the crocodile, that is, extending between the anterior and posterior mandibular foramina, quite as in the amphibians. It is only in those primitive reptiles in which the anterior foramen appears to be absent that the bone extends from the symphysis to the posterior foramen, as shown in *Captorhinus* and *Labidosaurus* (Fig. 15), for instance. In reality, however, in both these genera, as also in *Dimetrodon*, and other forms, there is a small foramen at the extreme front end of the bone, near the symphysis. The anterior foramen in the crocodile is small (Fig. 12), as in *Pantylus*, and is situated near the symphysis. One can easily understand that, in these reptiles, it is the anterior bone which has been lost, that the recession of the symphysis has brought about its suppression, rather than its elongation or fusion with the posterior bone. If this is the real explanation of the loss, it follows that the posterior bone is the true splenial, and that the anterior one should retain the name infradentary, as originally given to it in the fishes and as used for it in *Eryops* by Branson.

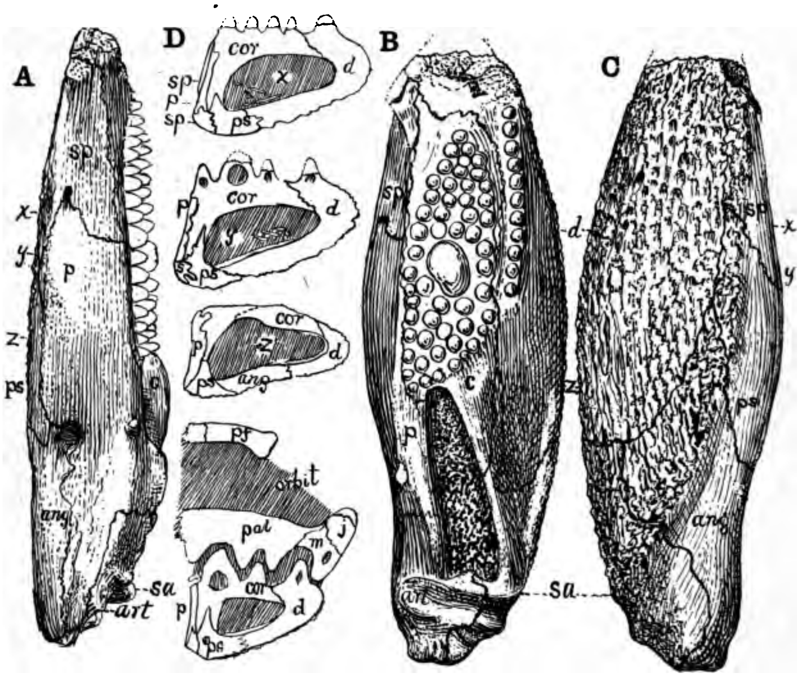

FIG. 27.—*Pantylus:* Mandible; *A*, right mandible, from inner side; *B*, the same, from above; *C*, same, from below; *D*, sections corresponding to letters.

Vertebrae.—Four series of vertebrae, in blocks of clay sandstone, were preserved in association with parts of three skulls. The most anterior of these includes some five or six associated with a part of the pectoral girdle, ribs, and a patch of dermal scutes. The second series is five in number, with ribs. The third, also five in number, is from the posterior dorsal region with ribs in articulation, limb bones, and fragments of the pelvis. The fourth series includes four anterior caudals with chevrons (Fig. 28). The anterior vertebrae agree so well with those figured and described by me as *Ostodolepis* that there would seem to be little doubt of their generic identity. The ribs are distinctly dichocephalous, and the spines throughout are short or vestigial. The arches are in no wise thickened and expanded, as is characteristic of other known cotylosaur vertebrae. Indeed, so aberrant are the vertebrae of *Ostodolepis* for a cotylosaur that I referred them unhesitatingly to the Theromorpha. The chevrons are peculiar among Permian reptiles in their attachments to large facets situated almost wholly on the hind ends of the centra and not between them.

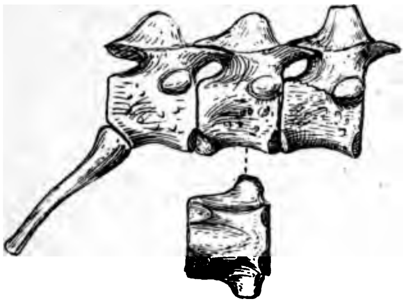

FIG. 28.—*Pantylus:* Caudal vertebrae and chevron. Enlarged one-half.

Girdles and limbs.—Parts of the pectoral girdle are preserved on the most anterior of the blocks, consisting of a nearly complete interclavicle overlain by the lower part of the scapula, and more or less of the two clavicles. A part of the scapula has been detached and lost, exposing the interclavicle. The interclavicle is very peculiar, unlike anything I have hitherto observed among reptiles, and more like that of *Ornithorhynchus*, as shown in Fig. 29. The anterior end is forked, each branch articulating with a slender clavicle. Posteriorly the bone is dilated in a fanlike manner and is thin. So different is the bone from the interclavicle of other reptiles that one might be tempted to call it a sternum, the interclavicle being absent. If so, it is the first appearance of the sternum in geological history. But I cannot believe that it is the sternum.

A fragment only of the coraco-scapula is preserved, as figured. I can find no postglenoid facet, nor can I distinguish any sutures. Of the limb bones, the two ends of a femur and of a humerus, parts of two or three epipodials, and three connected phalanges are all that I recognize. The propodials, so far as they go, resemble most those of a small *Labidosaurus*, but are more slender, the distal end of the humerus being much narrower. The legs were more slender than in that genus, about as slender, perhaps, as in species of *Captorhinus*. I do not figure these fragments, since I am confident that further exploration of the locality whence these specimens came will reveal more perfect ones.

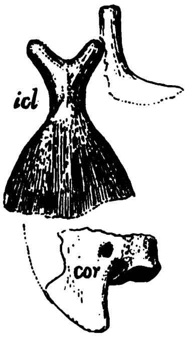

FIG. 29.—*Pantylus:* Interclavicle (*icl*) and coracoid (*cor*). Natural size.

Dermal armor (Fig. 30).—Lying over the ventral surface of the anterior vertebrae, just back of the interclavicle, there is an oval patch of dermal scutes 30 mm. long and 20 mm. wide. In the lumbar region, on the ventral side of the vertebrae, there is a smaller patch of about fifty scutes. The separate scutes join each other closely in irregular lines; they vary in diameter from ½ mm. to 1½ mm.; I count about one hundred in an area 10 mm. square. The individual bones are thin and have a smooth surface, showing no marks of external corneous scales. That these bony scutes covered closely the whole undersurface of the body back of the neck is quite certain; that they covered the body throughout I have no doubt, though positive evidence of this is yet lacking. In *Ostodolepis* (Fig. 31) the underside of the abdomen was sheathed with thin overlapping scales, which I believe, as stated in the description of the genus, were subdermal. No evidence of such scales is visible in the present specimens, and until such evidence is forthcoming the name *Ostodolepis* may be retained as a probable though yet uncertain synonym of *Pantylus*.

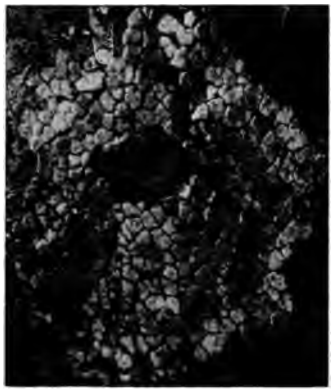

FIG. 30.—*Pantylus:* Dermal plates. Twice natural size.

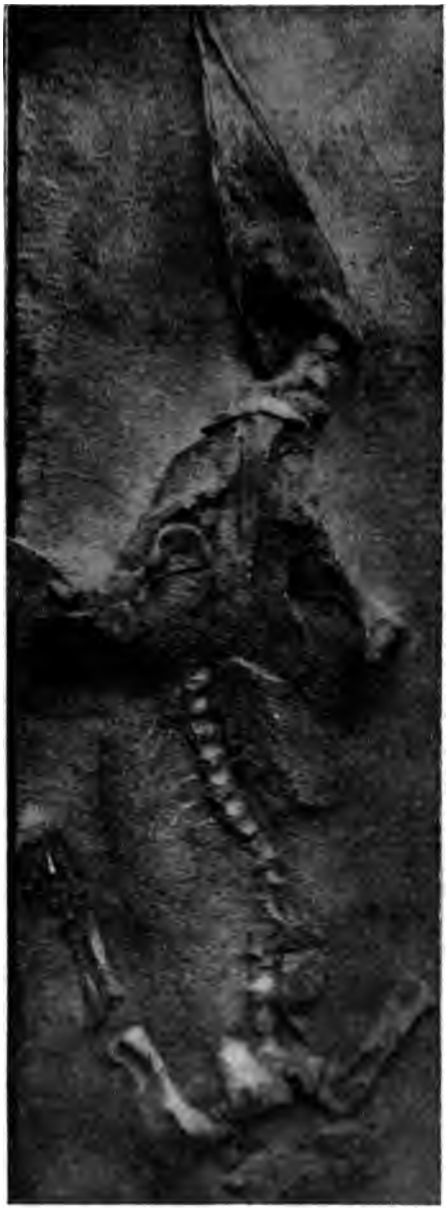

FIG. 33.—*Theropleura:* Part of skeleton, from below, in original matrix. One-sixth natural size. No. 690.

far back as the beginning of the tail, with all four propodials in articulation.

The bones, as usual in such nodules, are very perfectly preserved, showing no distortion and but very slight displacement anywhere. The cadaver had evidently come to rest in a supine position, as shown by the gradual slope of the propodials dorsad and the horizontal position of the vertebral column. The specimen is of especial interest, because it gives, almost for the first time in a Texas vertebrate, the normal articulations and associations of the skull, girdles, ribs, vertebrae, and limbs. The vertebrae have a somewhat sinuous curvature, and the skull is on a more dorsal plane than the pectoral girdle. The photographic figure (Fig. 33) shows the specimen as it has been uncovered and imbedded in plaster. In the line drawing (Fig. 34) I have figured as accurately as possible the relations of the bones, their shapes, and position, as completed from the two sides. To complete

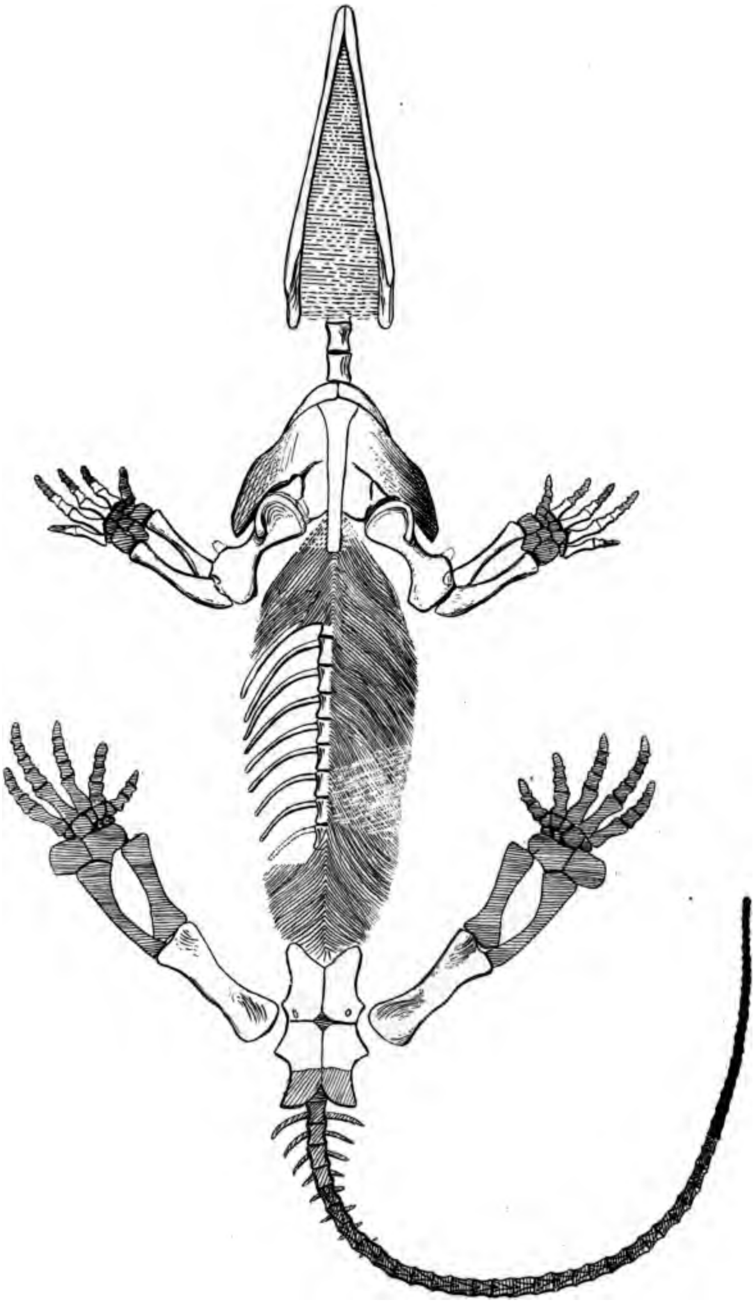

FIG. 34.—*Theropleura:* Skeleton, from below, as restored from specimen No. 690, the barred parts from specimen No. 671 (*Ophiacodon*).

the picture of the skeleton I have added in barred outlines the remaining parts from *Ophiacodon*, which is the more easily done as the two specimens from which the drawings are made are of identical size and proportions and of doubtful generic distinction.

The lower part of the skull is preserved in a normal and undistorted condition. The hard matrix between the slender mandibles cannot be removed without danger, preventing a view of the palate, which doubtless is preserved in the rock. The mandibles are of almost precisely the shape and size of those of *Ophiacodon*, as figured by the writer and Dr. Case.[1] They show the teeth imperfectly on the right side. They are slender and recurved, as in *Ophiacodon*, but appear to be more flattened. On the left side (the right of the figure) the maxillary teeth are visible in large part, but have suffered somewhat in preparation. They are somewhat longer than the mandibular teeth and are distinctly recurved and sharply pointed. They also appear to be more flattened than in *Ophiacodon*. The longest tooth, measuring 14 mm. in length by 6 mm. in breadth, occurs about 115 mm. back of the front end of the skull, not as far back as the longest tooth in *Ophiacodon*. The mandibles, as is seen, are very slender.

The clavicles and interclavicle differ in no noteworthy respect from those of *Ophiacodon*. The right scapula-coracoid is complete and is closely articulated in midline with the left coracoid, above the interclavicle. So far as it can be compared with the scapula of *Ophiacodon*, no differences can be observed; like that of the latter genus it is rather broad above. The metacoracoid is only imperfectly visible. A large part of the left scapula was lost through erosion. Both humeri are in position, in close articulation in the glenoid fossae, and each with its inner angle about 35 mm. from the midline of the interclavicle. That of the right side lies nearly horizontal; that of the left is rotated inward a little, and its outer end is partly destroyed. They are each directed outward and backward at an angle of about 45°. Of almost precisely the same length as those of the specimen of *Ophiacodon*, they differ in having a somewhat stouter shaft and a less produced entocondyle. The proximal ends of the right ulna and radius are in position; those of the left side, as already mentioned, were found in a separate nodular mass, and have been incorrectly placed in apposition with the right femur in the mounted specimen. Each of the forearm bones and four metacarpals corresponds precisely in length with the bone of *Ophiacodon*. The ulna seems to be more slender proximally. Phalanges of some of the fingers lie folded back over the carpus.

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[1] Description of a Nearly Complete Skeleton of *Ophiacodon* Marsh," *Publications of the Carnegie Institute*, No. 181, p. 39.

Of the bones of the pelvis, the pubis agrees well in length and breadth with the pubes of *Ophiacodon;* no tuberosity is observed on the lateral margin. The proximal part only of the ischia is present; it does not differ from the corresponding part of *Ophiacodon*. Both femora are preserved in close articulation in their acetabula, directed forward and outward at an angle of about 45°, and also somewhat dorsad. The right head lies 40 mm. from the midline; the left 55 mm. Throughout there has been a very slight thrust to the left side. The femur has a very distinctly stouter shaft than that of *Ophiacodon* and the outer condyle is not produced as much. The fourteen presacral vertebrae visible from the ventral side differ in no respect from those of *Ophiacodon*.

Most interesting of all the features shown in this specimen are the ventral ribs (Fig. 35), which are preserved very fully in what is evidently their natural relations and positions. They cover the ventral surface between the coracoids and the front ends of the pubes, sheathing closely the underside of the abdomen. Back of the coracoids they are underlain in the middle for about an inch by the posterior end of the interclavicle. The individual bones are about 1½ mm. in width, flattened or subcylindrical rods lying closely contiguous with each other. The longest continuous lines, in a gentle sigmoid curve, measure 145 mm. in length. The central part of each, or at least of all those of the anterior half, is an unpaired, V-shaped, somewhat dilated bone closely joining the others and with cylindrical branches which are continuous without break or intercalations for about two inches from the median line. Beyond this central piece each branch is composed of an indeterminable number of separate bones, joining each other by a long, close, splint-like union. The longest piece that I can find is scarcely more than an inch in length, from which I conclude that there were at least four on each side; there may have been more or fewer. In the first 50 mm. back of the end of the interclavicle there are eight of these central dilatations; in the succeding 50 mm. twelve or thirteen. Exteriorly, toward the front, fifteen of the rods occupy a space of one inch. In Fig. 35 I show several of the central pieces from about an inch and a half back of the end of the interclavicle, and a number of the longest rods, with divisional lines showing the relations of the separate pieces.

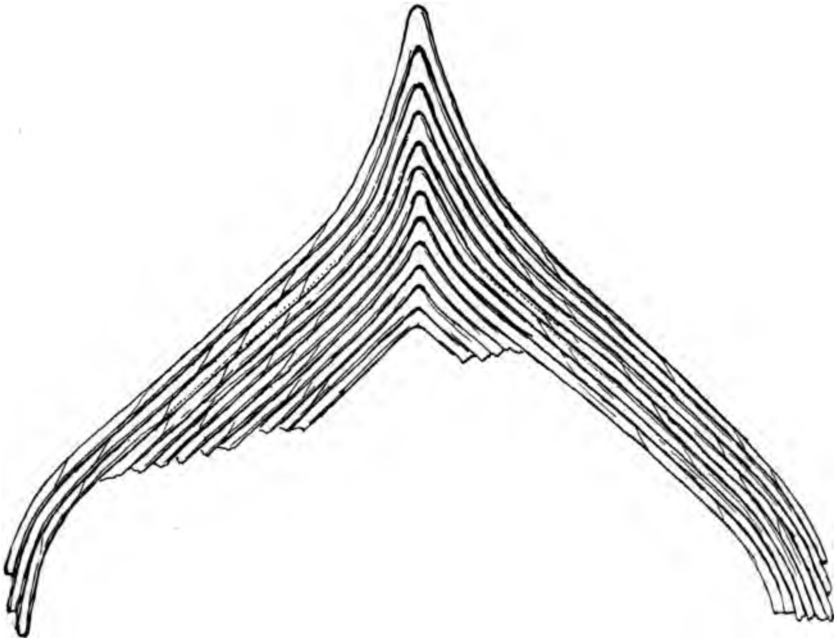

FIG. 35.—*Theropleura:* Anterior parasternal ribs. Two-thirds natural size. No. 690.

It will be seen from the figure that these ribs extend on each side to about opposite the ends of the dorsal ribs, as they lie in the matrix. It is evident that, in front, they filled out the space between the ends of the ribs in life, but that, posteriorly, they did not extend upward on the sides of the abdomen to the ends of the short ribs. Altogether they form a flattened, boat-shaped mass of contiguous flexible rods, gently convex below and slightly turned up on the sides.

ORIGIN OF THE STERNUM

The theory now universally accepted and taught of the origin of the breastbone, in the Amniota at least, is that of Gegenbaur and Götte, which in brief is that it has been derived from the fusion in the midline of the distal or ventral ends of dorsal ribs. Götte, however, urged that this theory would not apply to the modern amphibians (a sternum is unknown in fishes and the Stegocephalia), but said that in this class the so-called sternum had arisen from "Bauchrippen," which he believed to be a "selbstständige Bildung die mit dem im Rückentheile bleibenden Rippen in gar keiner genetischen Beziehung stehen noch einst gestanden haben kann."

Ventral or abdominal ribs, the parasternum or gastralia, as they are variously called, occur in all living and extinct orders of reptiles, as well as the earliest birds. Among living reptiles they are found in their most primitive form in *Sphenodon* as a series of slender, shallowly V-shaped rods, composed each of three pieces, a median, unpaired, somewhat dilated one, and two lateral ones. Their number is several times greater than the corresponding vertebrae. Among the Squamata they have been observed of late years in two genera of which I have knowledge. In *Tiliqua*, Beddard has described them[1] as several rather widely separated, chevron-like bones back of the sternum. In *Trachysaurus*[2] the same author found seven, the first four united in the middle, the posterior ones separated. In the Crocodilia they are few in number, corresponding with the vertebrae, each composed of a pair of median bones with a long and slender one on each side attached to its end. In the Chelonia they form three pairs of the bones of the plastron, the hyo-, hypo-, and xiphiplastra. In the Ichthyosauria, Plesiosauria, and Choristodera the much stouter and stronger ventral ribs are transverse in position, not at all V-shaped, with a median straight or nearly straight rod, and one or more pieces on each side. In all these they are three or more times as numerous as their corresponding vertebrae. In the Pterosauria, the later ones at least, there are two or possibly three median, unpaired, shallowly V-shaped flattened bones immediately back of the well-ossified sternum and contiguous with its ziphisternal process. Back of these there is an undetermined number of paired, flattened bones, which may or may not have had a distal piece on each side. In all probability the so-called prepubis is merely the last pair of these bones, united in some, separate in others. They are not more numerous than the vertebrae. Ventral ribs also occur in the Phytosauria and Dinosauria. Among the American Permian reptiles slender rods like those of *Theropleura* have been observed in *Captorhinus* and *Labidosaurus* of the Cotylosauria, and in several genera of the Poliosauridae. In *Ostodolepis*, which doubtless is the same as *Pantylus*, the abdomen was sheathed with thin, overlapping, osseous scutes, beneath a dermal osseous covering. The discovery of ventral ribs often comes slowly, and it is very probable that more of the early reptiles will, eventually, be found to possess them.

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[1] *Proc. Zoöl. Soc.* (1904).

[2] *Op. cit.* (1906).

Ventral ribs have been assumed to be of dermal origin and to have sunk into the ventral muscles from the skin, as first suggested by Credner. In his description of the ventral rods of *Trachysaurus* Beddard speaks of them as "gristly" or cartilaginous, and observes that they lie in the most ventral layer of the muscles; and this doubtless was the position of these ossifications in all the extinct reptiles and amphibians in which they have been discovered. Nor can there be any doubt that the elements in the reptiles are morphologically quite the same as the ventral scutes of the Stegocephalia, especially the Branchiosauria. In *Cricotus* they form, as in *Theropleura*, a complete, compact, ventral sheath, arranged in a V-shaped pattern, but with the individual elements of the branches much more numerous. Doubtless in this and all other known Stegocephs they were covered with the skin, which may have had ossifications of its own, as in the caimans. Primitively the number between the coracoids and pelvis was very great; in *Theropleura* there are more than two hundred on each side covering fourteen vertebrae; and only in the crocodiles or possibly the pterodactyls have they been reduced to a number equivalent to the dorsal ribs and vertebrae.

It is thus very evident that these ossifications, as affirmed by Götte, have "keine genetische Beziehung" with the true ribs; not only because of their positions in the abdominal muscles, but also because of their great numbers. The whole tendency of evolution has been to reduce their number and increase their size, especially in water animals. Boulenger and Beddard, in *Trachysaurus*, have observed that in some instances among lizards some of the true ribs meet back of the sternum and may be united. But I am confident that Beddard was right in suspecting that in all such cases the middle portion is merely the ventral ribs which have become united to the ends of a dorsal rib. Primitively the coracoids met broadly in the middle line, and we know of no fossil form in which the anterior or any dorsal ribs met or even approached each other in the middle above or behind them.

The position of the ventral ribs in this specimen and in the before-mentioned specimen of *Ophiacodon* shows that they extended above the posterior end of the interclavicle to or nearly to the entrant angle between the metacoracoids. The anterior ones thus occupy precisely the position of the sternum in many living lizards. Why then should one assume from purely embryological data that they later disappeared in this region, to be replaced by similar structures as extensions of the true ribs, apparently for the sole purpose of developing a sternum? Paleontologically the evidence of the evolution of the sternum from the anterior ventral ribs seems complete. Doubtless there was a fusion of the most anterior median pieces retaining their lateral branches, which later became attached to the ends of the dorsal ribs and yet remain in modern reptiles and birds as the so-called sternal ribs. That, embryologically, the sternum first appears in mammals as a pair of elongated cartilages with attached rib branches is only what one might expect. Certainly the unpaired bones were originally paired, and so remain in the modern crocodiles.

With this origin of the sternum proved, I think, the name —parasternum—given by Gegenbaur to the ventral elements seems the most fitting.

In my study of the type specimens of *Ophiacodon* Marsh I was struck with the general resemblance of the bones (which I referred to the genus in the Yale Museum) to the corresponding bones of *Theropleura*. Later, in the study of the very perfect specimen of *Ophiacodon* from New Mexico described by the writer and Dr. Case,[1] I was convinced that "it is probable, if not certain, that *Theropleura* is a closely allied if not identical genus," though at the time I knew the latter genus only from figures and descriptions. I later reached the conclusion that the two genera were distinct in their teeth as shown by several specimens, two of which are herewith figured (Fig. 36) from the Craddock bone-bed of Texas. They are of an animal considerably larger than the one herein discussed, and differ very materially in their broader, flattened, and cutting teeth. However, I am about convinced now that these specimens belong to an entirely different, yet unnamed, genus. The extraordinary resemblances throughout the two specimens of *Ophiacodon* and *Theropleura*, as also their remarkable correspondence in proportions, have now nearly convinced me that such differences as are discoverable are nothing more than specific in value. The mandible of *Ophiacodon*, for instance, measures 290 mm., that of *Theropleura*, 295 mm.; the humerus of the former, 110 mm., of the latter, 102 mm.; the femora 110 and 115 mm., respectively. The total length of the specimen of *Ophiacodon* to the acetabulum, as mounted nearly in the position in which it was found, is 920 mm.; that of the specimen of *Theropleura*, 950 mm.

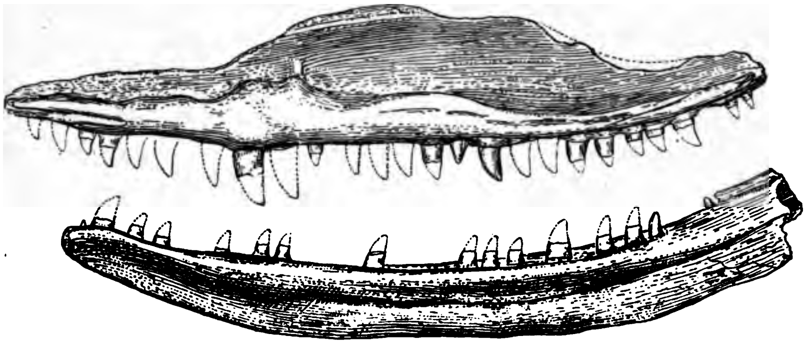

FIG. 36.—*Genus novum*, Ophiacodontidae: Right maxilla and right dentary, inner sides. Two-fifths natural size. Craddock bone-bed.

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[1] *Publications of the Carnegie Institute*, No. 180, 1913, p. 59.

However, there are still other possibilities of generic differences being found in the skull, and it will, I think, be better to wait for further confirmation before displacing the name *Theropleura*. For the present, however, the only safe generic distinctions are the localities whence the specimens come.

The probable identity of these two genera, as also the ocurrence of the genus *Edaphosaurus* (*sensu stricto*) in the two localities, is of immediate stratigraphic interest. *Theropleura* has never been recognized, to the best of my knowledge, in the upper Texas beds; nor has *Edaphosaurus*, as I define the genus. The layer in which the present specimen was found Mr. Miller thinks is the same in which various specimens of *Pantylus* have been found, as also the type specimens of *Broiliellus*, *Glaucosaurus*, and *Mycterosaurus*, together with numerous specimens of *Captorhinus*. It is near the lower part of the Clear Fork, if not actually in the Wichita, as Case defines the beds, and at least four hundred feet, if not more, below the uppermost part of the Clear Fork.

In my earliest studies of the New Mexico fauna I was convinced that their horizon corresponded to the lower horizons of the Texas deposits, chiefly because of the absence of those forms like *Labidosaurus* so characteristic of the Clear Fork beds. The close resemblances, to say the least, between *Ophiacodon* and *Theropleura* are another and more decisive bit of evidence in the same direction. I think it may now be accepted as fairly well proved that the El Cobre and Puerco deposits, or at least those which have yielded the known fossils, are the equivalent of the lower beds of Texas. Possibly future search may bring to light fossils from higher beds in New Mexico that will correspond more with those of the Clear Fork of Texas. At present they are conspicuous by their absence.

PUERCOSAURUS OBTUSIDENS N. GEN. AND SP.

The present genus is based upon three specimens, a dentigerous portion of the left mandible and two imperfect skulls. The mandible (Fig. 37, *D*) was found accidentally in the laboratory in removing the matrix from the skeleton of *Ophiacodon* recently described. It came from the Miller bone-bed on Poleo Creek, in the vicinity of Arroya de Agua, New Mexico. Doubtless the whole mandible was present in the matrix, but it was only by the fortunate chipping of the matrix that it was discovered. The two skulls were found by Mr. Miller in 1911 on the Puerco, a few miles below Arroya de Agua.

The mandible is deep posteriorly, and its surface is rather smooth. The teeth are all flattened and obtuse, with slight indications of rugosity at the top of the crown. The four front ones are a little longer than the following and also more slender. They have a cylindrical or somewhat flattened shaft, obtusely conical at the top. The eighth and tenth teeth are much broader at the base, though but little or no higher. Following the tenth tooth there are six smaller and rather more conical teeth, which are nearly as broad at the base as they are high. By excavating below the base of the seventh tooth, the alveolar part of the jaw is shown to be narrow, without additional rows of teeth. This specimen may be considered the type of the genus and species.

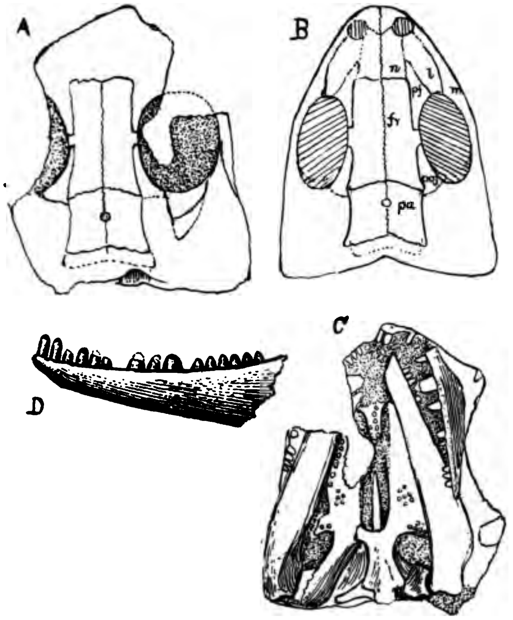

FIG. 37.—*Puercosaurus obtusidens: A*, skull (No. 745), from above; *B*, restoration; *C*, the same, from below; *D*, left mandible (No. 746), from without. *A*, *B*, *C*, enlarged one-half; *D*, enlarged two diameters.

In the quarry in which this specimen was found there were numerous indications of small reptiles, of which, however, very few specimens could be secured, so frail and fragile were they; they were usually discovered by their casts in the sandstone. One specimen, consisting of a series of vertebrae, may belong with this form. The vertebrae are much like those of *Caporhinus*, but have a short, slender spine.

The two skulls that I associate with this species are both incomplete. The one shown in the figures is more flattened than the other, but is otherwise better preserved. From the two specimens I have made the reconstruction shown in Fig. 37, *B*, *C* with considerable assurance. The face may be a trifle narrower and the posterior part of the skull a little wider than is shown. The skull is low and relatively broad with very large orbits situated about the middle anteroposteriorly. The frontal bones are long, the parietals relatively short, with the parietal foramen situated in front of their middle. The prefrontals and postfrontals meet very nearly but not quite over the orbits. Back of the parietals I am not quite sure of the identification of small dermosupraoccipitals. The postorbital is a large bone. I cannot be sure of the limits of the squamosal and quadratojugal. The premaxillae have, apparently, four teeth each, though the fourth may really belong with the maxillae. They are, like the four anterior teeth of the mandibles, slender and small. Each maxilla shows definitely fourteen, or, if the fourth ascribed to the premaxilla belongs to this bone, fifteen teeth. There may be a very small one back of these, but no more. The eighth of the maxillary series is much larger than the others, either in front or behind, though not much longer. Like the eighth and tenth of the mandible it is oval in cross-section, and has a rounded top. The posterior teeth are slender and less elongate. They extend as far back as the posterior part of the orbits.

The palate is of the *Captorhinus* type. The narrow basisphenoid articulates with the pterygoids by definite basipterygoid processes. The interpterygoidal space is not wide and has in it a slender parasphenoid process which extends half-way to the vomers. There are patches of teeth of indefinite numbers on each pterygoid plate, and a row on the summit of the ectopterygoid part. The palatines also have a row of large teeth situated close to the alveolar margin of the closed mandible. In front the vomers are elevated and have each two rows of tubercular teeth, bordering the margins of the internal nares. From each side of the these characters from the same viewpoints, and, in consequence, no two persons whose opinions are worth while ever wholly agree as to classification."

Under these circumstances conservatism seems to me the better part. I have refrained from expressing my own opinions as to the genealogies and relationships of these primitive tetrapods until our knowledge should furnish a surer foundation for theories and speculations. This does not mean that we should leave them unclassified. Our knowledge must be classified so far as possible in the light of what we actually know, and suggestions as to what that knowledge may lead to are always welcome. Professor Case thinks my attitude is too conservative; perhaps it is. We are prone to assume, in our conceit, that we are able *ab uno discere omnes;* inclined to construct elaborate genealogies and wide systems of genera, families, and orders, based upon a few well-known forms. In my experience such attempts seldom reach far, except to invite destructive criticism, which, however, is often valuable. As a matter of fact, for animals so widely different from later forms as are these paleozoic tetrapods, we know very little about them yet. We are attempting to measure them with uncorrelated yardsticks of much later or recent manufacture. Procoelous vertebrae are not an ordinal character among the Squamata or Crocodilia. Why then should we assume that amphicoelous vertebrae are an ordinal character among Permian reptiles? We assume that the streptostylic quadrate is an ordinal character in lizards until a lizard in all other characters is found with a fixed quadrate, when it becomes subordinal. We have pinned our faith to the openings of the temporal region as an unimpeachable ordinal character among reptiles. There must have been a time when it was variable and of much less than ordinal value.

I have attempted in the following pages to present a synoptic review of the generic, family, and ordinal characters of the American Permocarboniferous Amphibia and Reptilia, as I interpret them. I trust the attempt will serve as a sort of inventory of our present knowledge, regardless of my personal views as to its taxonomic application. I do not attempt to characterize the various proposed suborders of the reptiles, because, frankly, I do not know how to measure them, how to distinguish them from the families; nor am I at all sure, on the other hand, which are family and which are merely generic characters. Various suborders have been proposed: Diadectosauria, Pantylosauria, Labidosauria, Pelycosauria, Edaphosauria, Caseasauria. Probably most of them will be eventually recognized by those best qualified to judge as names of groups differentiated from each other by characters of higher rank than familial. The number of genera in each group has no bearing on its validity. At the present time the almost uniform tendency in zoölogy and botany, as well as in geology, is to elevate the lesser groups to higher rank, to erect new orders, classes, and systems. When it has been consistently done all around we shall be just where we began, so far as classification goes, and the only gain, or loss, will be a lot of new names to perplex and irritate the layman.

I have given the family characters in each case as based chiefly upon the best known genus, modified to include the less well known genera. It is quite certain that when these imperfectly known genera are better known differences will be found that will require either the severe pruning of the family characters or the separation of some of the genera into other or new families. I have previously commented on the fact that nearly every specimen showing differences has been described as a genus, and, as will be seen, a large proportion of the genera have been segregated into different families. Although we know more than seventy genera of American Permian tetrapods, in all certainty this number is only a small part of those which actually existed during Permian times. If it were possible to congregate all living reptiles in a single receptacle and then to select at hazard a few hundred specimens from among them, the probability is that nearly every specimen so selected would represent a distinct genus and that the number of families represented would be unduly large. If to this collection we could add all the reptiles which have lived since Eocene times, the probability is that each specimen haphazardly taken from among them would represent a different type. And that is what we are doing with the Permian collections. Again, in taxonomy, convenience is a negligible quantity. It matters not whether a genus includes one or one thousand species; its limits must be based exclusively upon morphological characters. The order Rhynchocephalia has but a single living species; the Squamata includes more than three thousand.

It is seldom that any two specimens found in the Texas Permian can positively be determined as of the same species, and I venture to say that the majority of the species hitherto described from these beds include but a single positively determined specimen of each—the type.

I offer, therefore, the following review of the American Permocarboniferous amphibians and reptiles as a summary of their known characters distributed in accordance with my own views, with which probably no other student of the fauna will wholly agree. Certain it is that some, if not many, of the characters which I class as familial will in future years, as we learn more of the fauna, be relegated to lower, or elevated to higher, rank. That the reader may judge of the basis for the generic distribution, I give, briefly, lists of the skeletal parts upon which our knowledge of each is based.

I can only hope that someone will attempt a similar synopsis of the foreign genera belonging to these and related groups of Permian age. I may add that only a very few of the genera mentioned in the following pages are unknown to me autoptically; the characters of very nearly all have been verified by the study of specimens. *Eosauravus*, from the Coal Measures of Ohio, is added in order to complete the survey of the American Paleozoic reptiles.

The illustrations, except as noted, have all been made by myself from specimens in Walker Museum. Figs. 70–77 are reproduced from an earlier paper by the writer and Dr. Case.

THEROMORPHA

There is not a little diversity of opinion among recent writers as to the ordinal limits and nomenclature of the American Permocarboniferous zygocrotaphous reptiles. Dr. Case, in the most recent expression of his views, considers them as constituting an order distinct from the so-called Therapsida, under the title Theromera, a term proposed by Cope in 1889. Dr. Broom believes that no major distinctions can be made between the American and African zygocrotaphous reptiles, but I am not aware that he has definitely expressed his opinion as to the name the order or superorder should bear; Mr. Watson, who agrees with Dr. Broom as to the close relationships of the American and African forms, has definitely proposed that they be called Therapsida, a name introduced by Broom a few years ago for the African reptiles. I am, myself, yet hesitant as to the homogeneity of all these diverse reptiles, but am inclined to the opinion that one term, for the present at least, should cover them all. But I am emphatically of the opinion that that term should not be Therapsida, in the support of which I can see no argument of merit. The questions in dispute seem to resolve themselves into the following:

Are the rules for nomenclature for genera and species applicable to orders and suborders?

Does the emendation of ordinal characters justify the emender in substituting new names? In other words, does the addition or subtraction of any genus or group to or from a recognized order render a new ordinal name necessary for the group thus emended? Or, to put it concretely, would the addition of *Araeoscelis* or *Protorosaurus* to the order Squamata, if confirmed, render necessary a new ordinal name for the enlarged Squamata?

To both of these questions I think the great majority of naturalists will answer decidedly, No. It is upon their answer, however, that the ordinal name of these Permocarboniferous reptiles depends.

The history of the classification and nomenclature of the American Permian reptiles will be found *in extenso* in Professor Case's chief works, and need not be repeated here. A summary, with a few additional facts, will suffice.

The name Pelycosauria, by which the American reptiles are best known, was first proposed by the late Professor Cope in *Paleontological Bulletin No. 29*, issued on May 8, 1878, as that of a suborder of Rhynchocephalia. The suborder was based upon the supposed absence of a quadratojugal arch, and the plate-like structure of the pelvis—that is, without pubischiadic openings—neither of which is correct in the present use of the term. He included in this suborder the genera *Clepsydrops*, *Dimetrodon*, *Embolophorus*, *Pariotichus*, *Bolosaurus*, and *Diadectes* of America, and *Pareiasaurus* and the Theriodontia of Africa. Of these, only the first two genera are certainly members of the group in its restricted sense, and the first three in any sense, at the present time. Two years previously, in 1876, Owen had described the known genera of Permian reptiles of South Africa under the orders Anomodontia and Theriodontia (exclusive of *Pareiasaurus*, which he included with the Dinosauria!). There can hardly be a dissent from the assertion that Cope committed an infraction of the simplest nomenclatural laws in thus subordinating the proposed ordinal name Theriodontia as a synonym of his newly proposed subordinal name Pelycosauria. As a matter of fact, both Baur in 1887 and Lydekker in 1890 rejected Pelycosauria as a synonym of Theriodontia. However, when *Clepsydrops* and *Dimetrodon* were shown to be very distinct in their more important characters the term Pelycosauria was resuscitated for them and their allies; and the name became justified. The extreme purist may insist that a name "once a synonym is always a synonym," and there can be no question that, as Cope proposed the term Pelycosauria, it included the forms then placed under the Theriodontia and displaced that name.

In December of the same year (1878) Professor Cope proposed the order Theromorpha, as follows:

> Scapular arch consisting at least of scapula, coracoid and epicoracoid, which are closely united. Pelvic arch consisting of the usual three elements, which are united throughout, closing the obturator foramen (f. puboischiatum). Limbs with the phalanges as in ambulatory types. Quadrate bone proximally united by suture with the adjacent elements. No quadratojugal arch.
>
> Pelycosauria. Two or three sacral vertebrae; centra notochordal; intercentra usually present. Dentition full.
>
> Anomodontia. Four or five sacral vertebrae; centra not notochordal; no intercentra. Dentition very imperfect or wanting.

This definition included, as previously, the Cotylosauria and the Theriodontia of Africa under the Pelycosauria. Again there may be a dispute as to the justification Cope had for reducing the ordinal term Anomodontia to a suborder and including it under the new order Theromorpha. It may be said in extenuation of his procedure that to retain it as the ordinal name would require a new name to replace Anomodontia in its narrower sense, as now generally used and as originally defined by Owen. However this may be, here was the first attempt at the definition of an order to include all the known African and American reptiles, and in this sense it must take precedence over all others. In this sense Theromorpha has been used within recent years by Broili in the last edition of Zittel's *Grundzüge*, and by the editors of the *Zoölogical Record*, and others.

My position is essentially this: Pelycosauria was proposed originally as a suborder of Rhynchocephalia, later as a suborder of Theromorpha. If the term is raised to an ordinal rank to include all of the American zygocrotaphous reptiles with a lower temporal vacuity, it will become necessary perhaps to substitute another and new name to replace it as a suborder, as was originally proposed. If we retain the name Theromorpha to include the American and African reptiles, the only change from its original content is the subtraction of the Cotylosauria, the addition of the new groups or forms since discovered, and the separation of the suborder Theriodontia from the suborder Pelycosauria. The argument for the retention of the name Anomodontia to include all the African and American single-arched reptiles from the Permian is that it was the first ordinal name proposed for any member of the group as now known; and that an American form (*Bathygnathus* Leidy) from Prince Edward Island was actually referred to the Anomodontia by Owen two years before Cope proposed the name Theromorpha. Broom, some years ago, gave reasons for adopting the term Dicynodontia, first used by Owen as a family of Anomodontia, in place of Anomodontia, following Huxley. Very recently, however, he has returned to the use of the name Anomodontia, but still clings to the term Cynodontia in place of Theriodontia, on the score of priority. Both of these groups, which he calls orders, he unites together with the Dinocephalia, Dromasauria, and Therocephalia under his superorder Therapsida, a term of recent introduction. And this last term is the one which both Broom and Watson, if I understand them correctly, would extend to cover the known African, European, and American groups. Broom, however, unlike most modern students, would raise all these groups to ordinal rank. The Pareiasauria, even, he calls an order under the superorder Cotylosauria!

Nor was Cope justified in the proposal of the new name Theromera for his order in 1889, because Seeley had previously defined the order Anomodontia as including all the then known American forms, that is in the sense of Theromera or Theromorpha. The name Theromorpha is not preoccupied as an ordinal name.

The foregoing are, briefly, my reasons for adhering to the ordinal name first proposed to include the American reptiles. If, later, the "Therapsida" of Broom are included under the order or superorder, the only alternative for Theromorpha is Anomodontia.

Class **AMPHIBIA**

Subclass **Stegocephalia** Cope

Amphibians with the temporal region completely roofed over. Paired nasals, frontals, parietals, dermosupraoccipitals, prefrontals, lacrimals, postfrontals, supratemporals, tabulars, jugals, and squamosals always, the postorbitals usually, and the interfrontal and intertemporals sometimes, present. A pineal foramen.

Order *TEMNOSPONDYLI* Zittel

Vertebrae composed of pleurocentra, neurocentra, and large intercentra.

Suborder RHACHITOMI Cope

Intercentra large, wedge-shaped, the pleurocentra paired (Fig. 38). Basioccipital ossified. Parasphenoidal vacuities large. Teeth more or less labyrinthine. Mandible with two splenials, three coronoids, and free prearticular. Humerus without epicondylar foramina. Coprolites showing spiral valves of intestine.

Family **ERYOPIDAE** Cope

Large, stout-limbed, subaquatic amphibians from one-half to three meters in length. Skull depressed, with lateral line canals and interfrontal bone. Two occipital condyles. Ear notch small. Scapula elongate, with large cleithrum. Interclavicle and clavicles rugose, of moderate size, not buckler-like. One sacral vertebra. Ribs with uncinate processes.

Eryops Cope (Figs. 38, 39, 40).—Two or three meters in length. Numerous specimens, including nearly all of skeleton; length of tail only in dispute. Texas; Oklahoma; New Mexico.

Parioxys Cope.—About one-half meter in length. "Orbits proportionally large, nares more nearly terminal than in *Eryops* and nearer to the lateral margin. The angle of the jaw is continued beyond the quadrate. The lower jaw is much narrower proportionally" (Case). Skull and a few vertebrae. Texas.

Anisodexis Cope.—"This genus and species are known only from a few fragments of the jaws and other bones, and cannot be compared with other members of the family Eryopidae, in which it is provisionally placed. The sharp, rather recurved teeth and the peculiarly imbricate appearance of the surface of the bones are totally different from any others from the Texas beds" (Case).

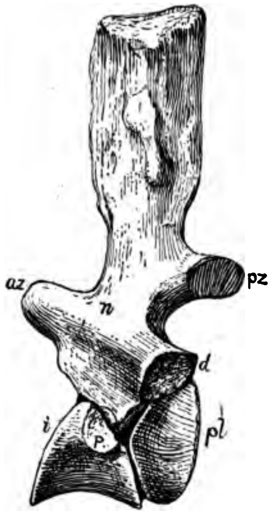

FIG. 38.—*Eryops:* Dorsal vertebra, from side. Two-thirds natural size. *pl*, pleurocentrum; *i*, intercentrum; *n*, neurocentrum; *az*, anterior zygapophysis; *pz*, posterior zygapophysis; *p*, parapophysis; *d*, diapophysis.

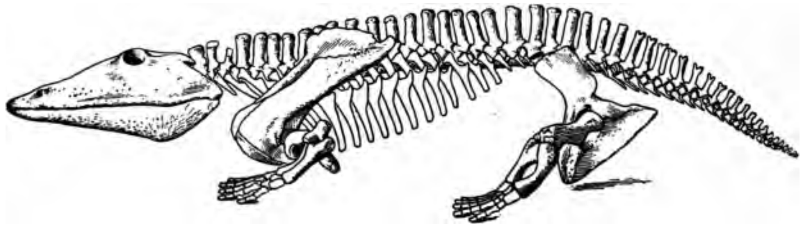

FIG. 39.—*Eryops:* skeleton, after Case. One-sixteenth natural size. From specimen in the American Museum.

Family **TREMATOPSIDAE** Williston

Thickset, large-headed, short-tailed amphibians about one meter in length. Skull not depressed, without lateral line canals or interfrontal or intertemporal bones. A median premaxillary vacuity and a large antorbital vacuity confluent with nares. Otic notch large, closed behind by the tabular. Two occipital condyles. Cleithrum? Mesopodials ossified. No dorsal armor.

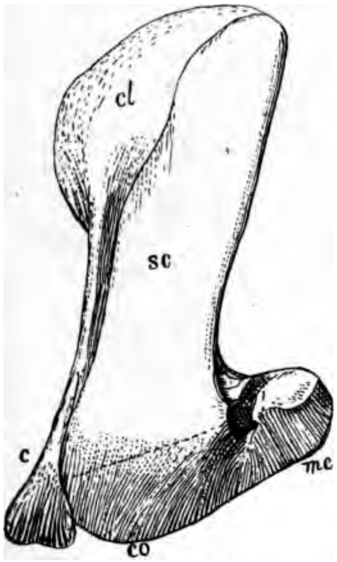

FIG. 40.—*Eryops:* Scapula (*sc*), coracoid (*co*), metacoracoid (*mc*), cleithrum (*cl*), and clavicle (*c*), from without. One-third natural size.

Trematops Williston (Figs. 41, 42).—Nearly all parts of skeleton. Clear Fork, Texas.

? *Acheloma* Cope.—Imperfect skull, vertebrae, and limb bones. Doubtfully a member of this family. Skull of similar shape, but openings unknown. Scapula transversely elongate. Texas.

Family **DISSORHOPHIDAE** Boulenger

Terrestrial, armored amphibians of about one-half meter in length. Skull short, subtriangular, moderately depressed, without lateral line canals or interfrontal or intertemporal bones. Ear notch deep, open behind or closed. Two occipital condyles. A median row of bony shields over cervical and dorsal vertebrae. Scapula with large cleithrum. Clavicular girdle small, not rugose. Mesopodials and pelvis fully ossified. Two sacral vertebrae.

Subfamily **Dissorhophinae**

Ear notch closed behind. Two dorsal shields over each vertebra, the outer one rugose.

Cacops Williston (Fig. 43).—Dorsal shields scarcely wider than vertebrae, the first one small. Several skeletons. Clear Fork, Texas.

Dissorhophus Cope.—Dorsal shields transversely elongate, covering the larger part of body; first shield elongate. Skull, vertebrae, girdles, and limb bones. Clear Fork, Texas.

Subfamily **Aspidosaurinae**

Ear notch open behind, a single rugose dorsal shield over each vertebra.

Broiliellus Williston (Fig. 44).—Dorsal shields elongate transversely, gently convex, not roof-shaped nor imbricated, slightly or not fused with spines. Skull subspinose. Skulls, vertebrae, limb bones. Texas; New Mexico.

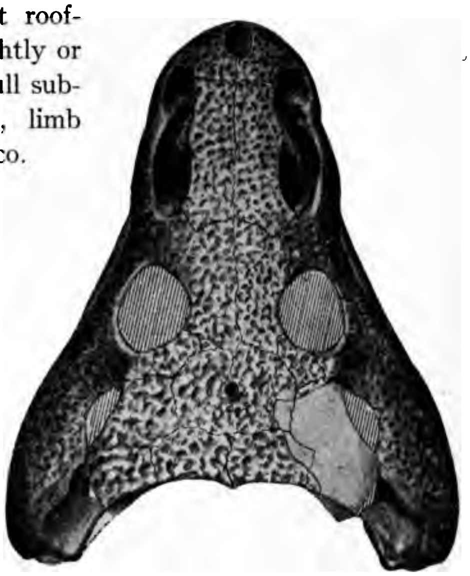

FIG. 41.—*Trematops:* Skull, from above. One-third natural size. No. 640.

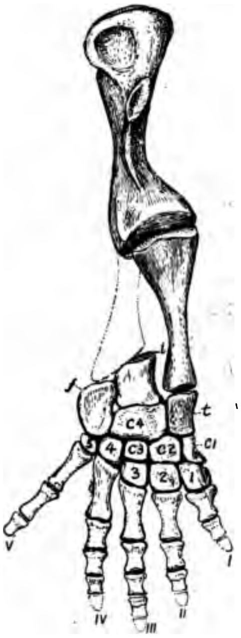

FIG. 42.—*Trematops:* Left hind leg, ventral side. One-half natural size. *f*, fibulare; *i*, intermedium; *t*, tibiale, *c*, *1*, *2*, *3*, *4*, centralia; *1*, *2*, *3*, *4*, *5*, tarsalia. No. 640.

Aspidosaurus Broili.—Dorsal shields narrow transversely, roof-shaped, imbricated, fused with spines of vertebrae. Skull and vertebrae. Clear Fork, Texas.

Alegeinosaurus Case.—Shields narrow, shallowly V-shaped, imbricated, not fused with spines of vertebrae. Vertebrae only. Clear Fork, Texas.

Family **ZATRACHYDIDAE** Williston

Moderate-sized amphibians, perhaps a meter in length, with flattened, broad, strongly sculptured skull, and sculptured spines of vertebrae. Orbits small, located posteriorly. Tabulars more or less projecting

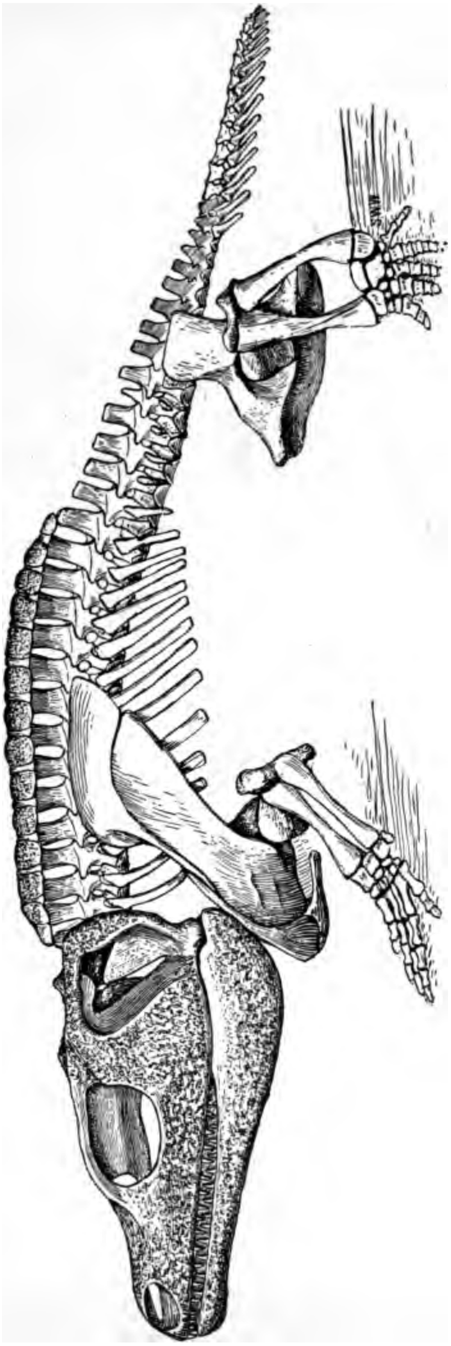

FIG. 43.—*Cacops*: Skeleton. One-third natural size. From mounted specimen in Walker Museum. No. 647

backwardly, with other angular projections on posterior part of skull. Two occipital condyles. Palate everywhere covered with minute, chagrin-like teeth. Mandible slender, not extending back of the articular surface of quadrates. Teeth very numerous, small, conical, without large palatal or jaw teeth. Vertebral centra unknown. Spines more or less sculptured and rugose, sometimes forming a more or less carapacial expansion, or more or less, sometimes extraordinarily, elongated and dilated above. Girdle and limb bones not known with certainty.[1]

Zatrachys.—Skull with a pair of broad, triangular, tabular projections behind. Spines of vertebrae not greatly elongated. Wichita beds, Texas.

Platyhystrix Williston (Fig. 45).—Skull

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[1] Probably a composite family which will include several species described as *Aspidosaurus*.

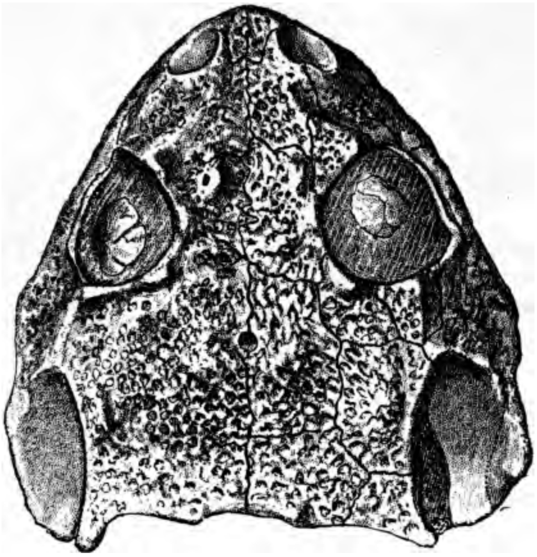

FIG. 44.—*Broiliellus:* Skull, from above. Three-fourths natural size. No. 684

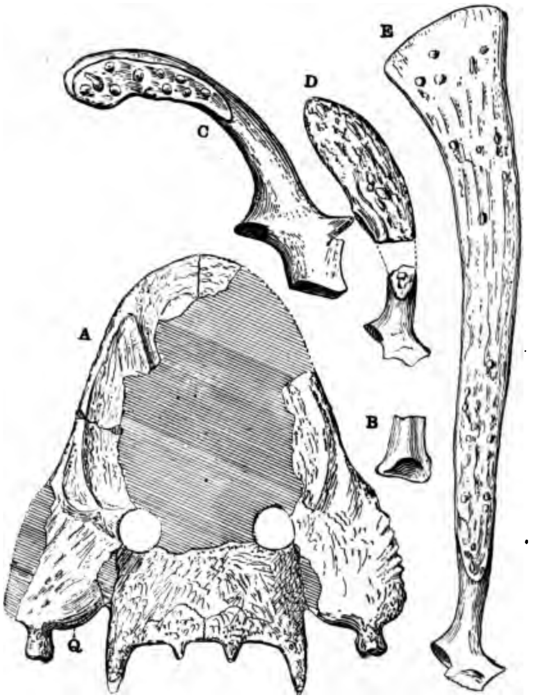

FIG. 45.—*Platyhystrix: A*, skull, from above; *B*, posterior end, right mandible; *C*, *D*, *E*, dorsal spines. One-third natural size.

with four projections backward from the cranial table, the tabular projections conical and slender. A projection back of the outer side of quadrates. Spines elongated and rugose, some of them much elongated, and dilated and flattened above. New Mexico.

Family **TRIMERORHACHIDAE** Cope

Aquatic amphibians of from one-half to one meter in length. Skull flattened, with lateral line canals. Eyes far forward, looking upward. An intertemporal bone. Occipital condyle single, concave. Pleurocentra small; spines short. Thirty presacral vertebrae, all ribbed, the sacral ribs undifferentiated. Body sheathed throughout by a thin, flexible, bony skin. Scapula short, broad;

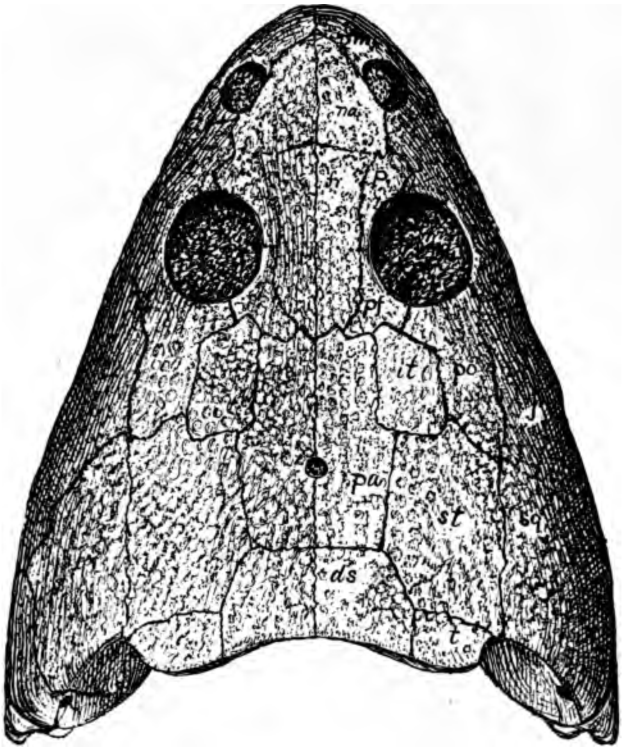

FIG. 46.—*Trimerorhachis:* Skull, from above. Two-thirds natural size. For explanations see p. 166.

no cleithrum. Clavicles and interclavicle very large, shield-like, rugose. Limbs small, poorly ossified; mesopodials and pubes (?) unossified.

Trimerorhachis Cope (Figs. 17, 18, 19, 46, 47).—Numerous specimens, for the most part from bone-beds. Tail and feet unknown. Clear Fork, Texas; Oklahoma.

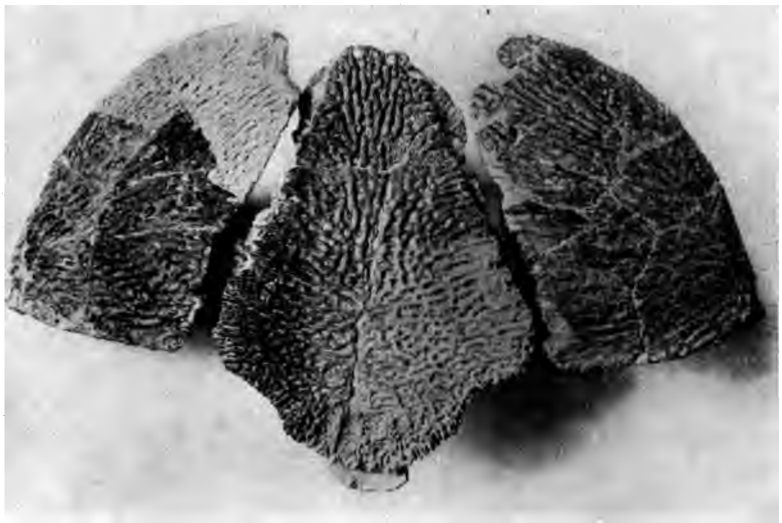

FIG. 47.—*Trimerorhachis:* Clavicular girdle, from below. Four-fifths natural size. No. 1076.

Genera *INCERTAE* Sedis

Tersomius Case.—Small amphibians, with a small, short, broad, flattened skull, from 25 to 32 mm. in length. Orbits large, situated a little in front of the middle. Dermosupraoccipitals and tabulars relatively small. Teeth slenderly conical, of nearly uniform size in maxillae, the premaxillary teeth small. Skulls only. Clear Fork, Texas.

Genus novum (A).—Resembles *Tersomius*, but the teeth less elongate, and somewhat flattened, very irregular in size. Imperfect skull. Clear Fork, Texas.

Genus novum (B) (Fig. 48).—Humerus very small, reptile-like, but lacking the entepicondylar foramen. Shaft very slender;

lower end of lateral tuberosity near middle of bone. Humerus only. New Mexico (Miller bone-bed).

Genus novum (C) (Fig. 49).—Skull broad, flat, depressed. Orbits near middle. Palate with a broad, flat plate covering the larger part of surface. Fragmentary skull. Puerco, New Mexico.

Goniocephalus Broili.—Imperfect skulls known of small size (not exceeding 25 mm. in length), especially characterized by the downward curvature of the posterior part of the parietal on the sloping occipital surface. Possibly a reptile. Clear Fork, Texas.

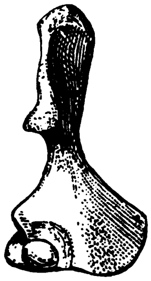

FIG. 48.—*Genus novum, B* (amphibia): Left humerus, ventral side. Enlarged one-half.

Suborder EMBOLOMERI

Vertebrae composed of arch and two, subequal, notochordal disks, the intercentrum and fused pleurocentra (Fig. 50).

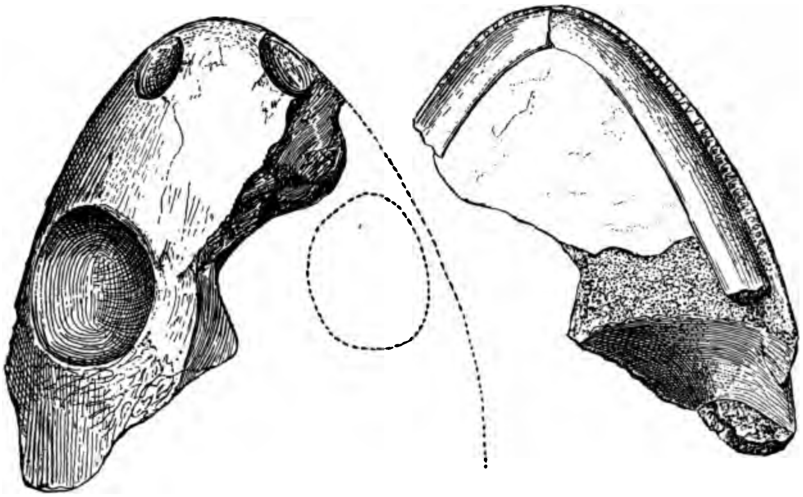

FIG. 49.—*Genus novum, C* (Temnospondyli). Skull, from above and below. Enlarged about one-fourth. No. 764.

Family **CRICOTIDAE** Cope

Slender aquatic amphibians of one or two meters in length. Skull elongate and narrow. Nares remote from anterior end of skull; orbits near middle, lateral in position. Tail long and slender. Ilium with long posterior projection. Abdomen covered with imbricated parasternal scutes. Skull with lateral line canals. Pectoral girdle and feet unknown.

Cricotus Cope (Fig. 51).—Teeth numerous and small, flattened, with cutting edge. Wichita beds, Texas; Illinois; Kansas; ? Bohemia.

Chenoprosopus Mehl.—Only the skull known and hence provisionally located in this family and suborder. No lateral line canals on skull. Teeth slender and conical. Miller bone-bed. New Mexico.

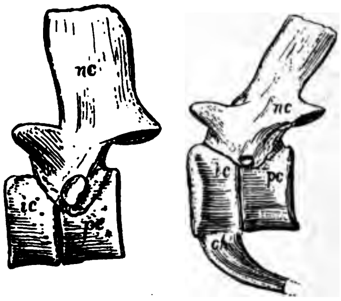

FIG. 50.—*Cricotus:* Dorsal and caudal vertebrae. One-half natural size. *ic*, intercentrum; *pc*, pleurocentrum; *nc*, neurocentrum; *ch*, chevron. Brier Creek bone-bed, associated with specimen No. 803.

Order *LEPOSPONDYLI* (*MICROSAURIA*) Zittel (*DIPLOCAULIA ?* Moodie)

Vertebrae holospondylous, no free intercentra. Chevrons a part of the centra. Teeth simple cones, not labyrinthine in structure.

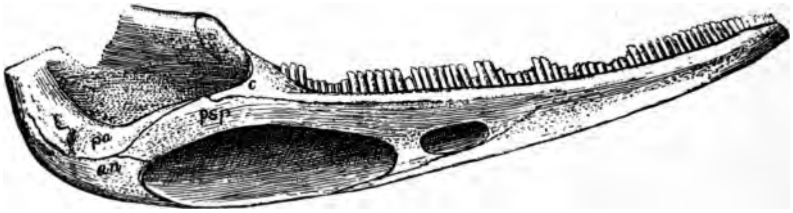

FIG. 51.—*Cricotus:* Left mandible, inner side. One-half natural size. No. 803

Family **DIPLOCAULIDAE** Cope

Aquatic amphibians, reaching a meter or more in length. Skull flattened. Eyes far forward, looking upward. Lacrimal excluded from margin of orbit; no postorbital. Skull with lateral line canals. Dorsal vertebrae with elongated dia- and parapophyses, the ribs double-headed, short. Clavicles and interclavicle large, shield-shaped, strongly rugose. Limbs small, poorly ossified; humerus with entepicondylar foramen. Tail long and slender. No dermal ossifications or parasternal ribs.

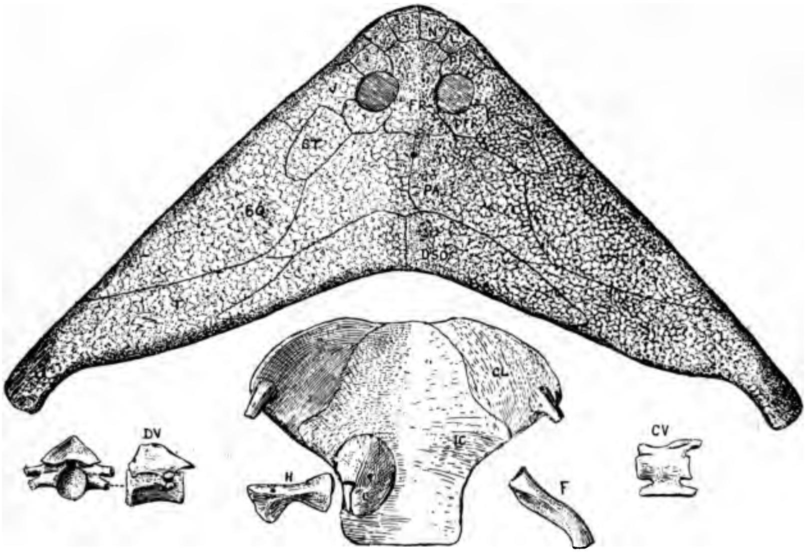

FIG. 52.—*Diplocaulus megacephalus:* Skull, from above; pectoral girdle, from above; vertebrae and propodials. *cl*, clavicle; *ic*, interclavicle; *c*, coracoid; F, femur; H, humerus; DV, dorsal vertebra, from side and front; CV, caudal vertebra. One-third natural size. No. 636.

Diplocaulus Cope (Fig. 52).—Numerous specimens of several distinct species or genera, the smallest forms with skull about one inch long, and without tabular horns. Illinois; Oklahoma; Texas.

Family **CROSSOTELIDAE** Williston

Slender, aquatic amphibians about one meter in length, with relatively small limbs. Skull, girdles, and most of limb bones unknown. Vertebrae with diapophyses and small facet in front of centrum for articulation of double-headed ribs. Spines short, broad, crenulated, with zygosphene and interlocking processes. Abundant and strong parasternal ribs. No entepicondylar foramen in humerus.

Crossotelos Case (Fig. 53).—Numerous series of vertebrae, humeri, and epipodials from Oklahoma bone-bed.

Subclass **Batrachia**

Temporal region of skull exposed, with loss of various dermal elements of the Stegocephalia. Basioccipital cartilaginous. Two occipital condyles. Vertebrae holospondylous; no free intercentra nor free chevrons. Ribs short. No pineal foramen. Front feet tetradactyl.

Order *CAUDATA* (*URODELA*)

Family **LYSOROPHIDAE** Williston

Slender, amphiuma-like amphibians from a third to a half meter in length; aquatic. Postfrontal, lacrimal, jugal, and quadratojugal absent. Orbits confluent with open temporal region. Prefrontal articulating with nasal, frontal, and parietal. Quadrate ossified; parasphenoid large. Vomers with teeth. Ceratobranchials and epibranchials ossified. Vertebrae notochordal, the arches not united above. No dermal or ventral ossifications. No chevrons. Limb bones very small, perichondral. Girdles and feet unknown.

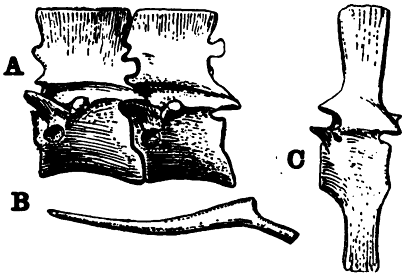

FIG. 53.—*Crossotelos*: *A*, dorsal vertebrae; *B*, dorsal rib; *C*, caudal vertebra. Natural size.

Lysorophus Cope (Fig. 54).—Numerous skulls, vertebrae, and limb bones known, occurring in nodular masses, coiled. Illinois; Oklahoma; Texas.

Class **REPTILIA**

Order *COTYLOSAURIA* Cope

Temporal region of skull imperforate, the surface rugose. Neck and legs short. Lacrimals, postorbitals, nasals, frontals, parietals, septomaxillae, epipterygoids, paroccipitals, quadratojugals, and dermosupraoccipitals present and paired, the lacrimal extending from nares to orbit. Teeth in paired premaxillae,

maxillae, prevomers, pterygoids, palatines and dentaries, thecodont or protothecodont. Pterygoids articulating with prevomers. A free ectopterygoid not yet demonstrated. Stapes large; quadrate fixed by squamosal, paroccipital, and pterygoid. Vertebrae deeply biconcave or notochordal; all vertebrae to basal caudals with free intercentra. A proatlas present. The capitulum of ribs articulates intercentrally, the tubercle with the arch. Interclavicle and clavicles always present, the former always with a long stem and none of them rugose. Coracoid, metacoracoid, and scapula fused in maturity. A supraglenoid and a supracoracoid foramen present. Pubis and ischium plate-like, without median, or lateral vacuities, the former always pierced by the obturator foramen. Acetabulum imperforate, formed by the three bones, fused in maturity. Humerus expanded at its ends into more or less divergent planes. An entepicondylar but no ectepicondylar foramen present. Radiale, intermedium, ulnare, pisiform, centrale, and five carpalia always present. Calcaneum, astragalus, and five tarsalia almost always present. Manus and pes pentadactylate. Phalangeal formula 2, 3, 4, 5, 3 (4). The coronoid extends along inner side of teeth in mandible; the splenial always enters into symphysis; a free prearticular bone.

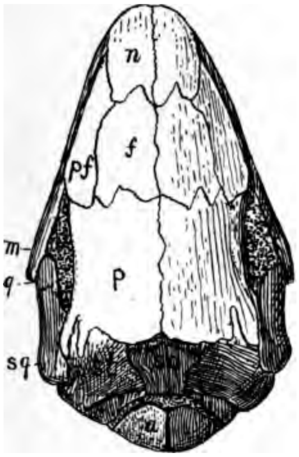

FIG. 54.—*Lysorophus:* Skull, from above. Enlarged five diameters. No. 636.

Family **LIMNOSCELIDAE** Williston

Elongate, subaquatic, or marsh reptiles about two meters in length; carnivorous and raptorial. Large dermosupraoccipitals and tabulars on upper surface of skull. Supratemporals present. Teeth of jaws in a single row, conical and more or less recurved; the premaxillary teeth elongate. Pineal foramen small. Occipital condyle concave. Arches of presacral vertebrae heavy; spines about as high as centra; no hyposphene; twenty-five presacrals and two sacrals; tail long. Ribs holocephalous, the anterior ones much dilated distally for support of scapulae. No parasternal ribs. A small cleithrum. Distalia of carpus and tarsus imperfectly ossified. Feet short and broad; ungual phalanges nail-like.

Limnoscelis Williston (Fig. 55).—Nearly complete skeletons, in Yale Museum. New Mexico.

Family **DIADECTIDAE** Cope

Invertebrate or plant-eating, lowland reptiles of one to three meters in length. Skull short and high, very rugose. Pineal foramen very large. Dermosupraoccipitals, tabulars and supratemporals present. Anterior teeth incisiform; posterior transversely molariform. Mandibles with large lower meckelian orifice. Occipital condyle concave. Arches of vertebrae stout, with hyposphenal articulation. Twenty-one or more presacrals, one or two sacrals; tail of moderate length. Ribs holocephalous, the anterior ones dilated distally. A cleithrum present. No ventral ribs. Distalia of manus and pes imperfectly ossified. Feet broad. Ungual phalanges broad and flat.

Diadectes Cope (Figs. 56, 57).—Spines of vertebrae short. Ilium with posterior process. Nearly complete skeletons. Texas; New Mexico (*Nothodon*, Marsh).

Diasparactus Case (Fig. 58).—Spines of vertebrae more elongate and cylindrical. Nearly complete skeleton. New Mexico.

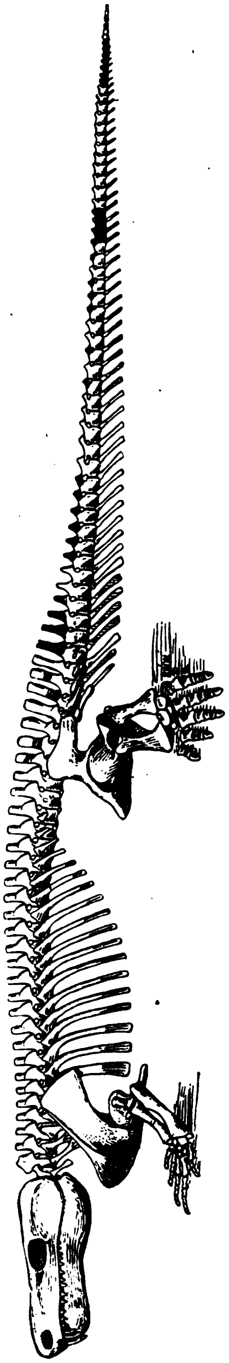

FIG. 55.—*Limnoscelis*: Skeleton, based on complete specimens, Peabody Museum, Yale University. One-twelfth natural size

Diadectoides Case.—Smaller. Spines of vertebrae and limb bones very short. One sacral vertebra. Ilium helmet-shaped. Teeth, vertebrae, pelvis, and bones of hind leg. Lower Clear Fork, Texas.

Animasaurus Case and Williston.—Only skull known. Pterygoids and vomers united to form a prominent keel; no interpterygoidal space nor foramen in basisphenoid. New Mexico.

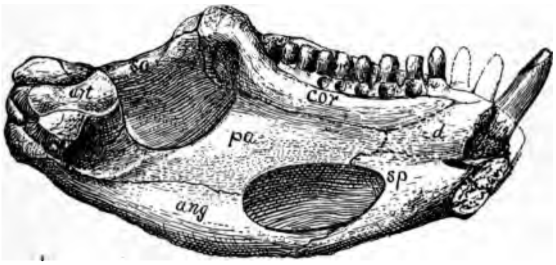

FIG. 56.—*Diadectes* (*Nothodon*): Left mandible, from within. One-half natural size. No. 675.

Bolbodon Cope.—Closely related to *Diadectes*. Distinguished by the greater thinness of the bones of the skull, and the less rugose sculpture of the surface (Case). One-half only of skull known. Texas.

Chilonyx Cope.—Skull large, markedly tuberculate, or subspinose. Only skull known. Texas.

Desmatodon Case.—Fragment of maxilla with four teeth, all that is known. Teeth transversely elongate, the outer half of the crown with a sharp apex, from which there is a sharp descent to the inner half, which is lower than the outer half (Case). Pitcairn, Pennsylvania.

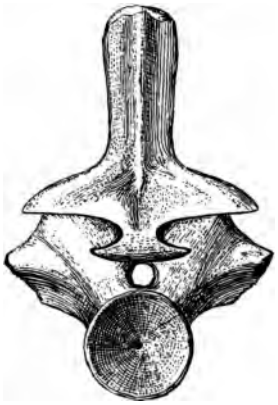

FIG. 57.—*Diadactes:* Dorsal vertebra, from behind, showing hypantrum. One-half natural size.

Family **BOLOSAURIDAE** Cope

Small reptiles. Teeth subconical, with a pointed outer or inner cusp, and a small heel-like one on the other side.

Bolosaurus Cope.—Only teeth and fragments of skull known. Systematic position disputed, possibly a member of the Theromorpha.

Family **PANTYLIDAE** Case

Invertebrate eating, terrestrial reptiles about a half-meter in length. Skull turtle-like in shape. Mouth filled with relatively large, conical teeth. A single row on maxillaries and dentaries; a large patch on coronoids. No pineal foramen. Supratemporal and tabular present. Arches of vertebrae not thickened, the spines very short. Ribs dichocephalous. Body, probably throughout, covered with a mosaic of small, smooth, bony scutes, not overlapping. Interclavicle dilated posteriorly. Limbs rather slender.

Pantylus Cope (Figs. 20–30).—Skulls, vertebrae, part of pectoral girdle, and fragments of limb bones known. Lower Clear Fork, Texas.

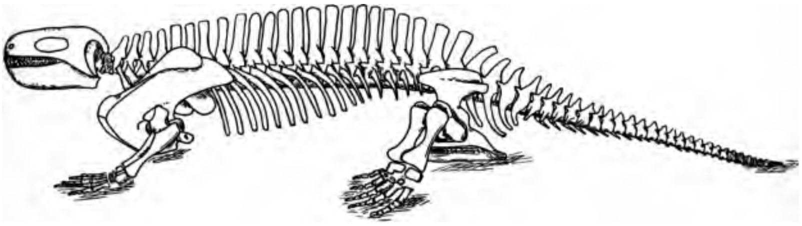

FIG. 58.—*Diasparactus:* Skeleton, after Case. One-twentieth natural size. From mounted specimen No. 679. Walker Museum.

Ostodolepis Williston (Fig. 31).—Vertebrae and ribs only. Walls of abdomen with numerous, overlapping, thin scales, probably subdermal. Probably identical with preceding. Clear Fork, Texas.

Family **SEYMOURIIDAE** Williston

Terrestrial, insectivorous reptiles about a half-meter in length. Skull subtriangular in shape, not flattened. Intertemporal, supratemporal, and tabular present. A large, stegocephalian-like ear notch. Teeth slender, conical, in a single row on maxillae and dentaries; incisor teeth not elongated. Pineal foramen small. Arches of presacral vertebrae greatly dilated; spines vestigial. Twenty-three presacral and one sacral vertebrae. Tail small. Ribs dichocephalous, the anterior ones dilated distally. No

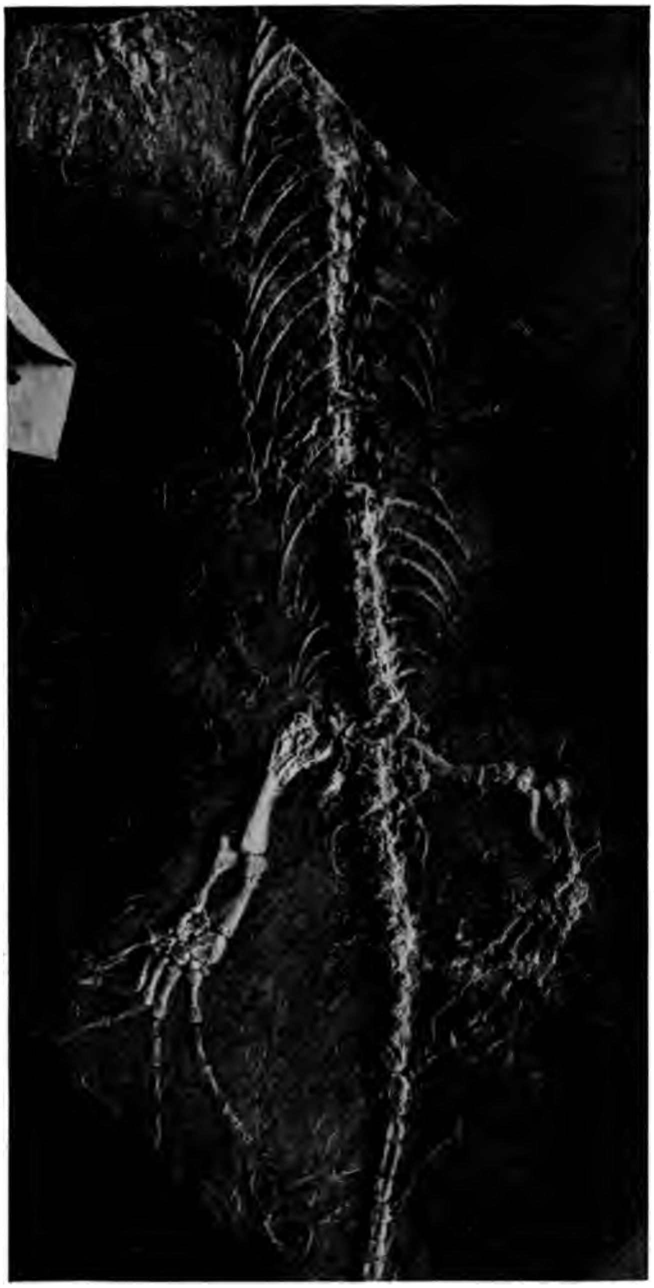

FIG. 62.—*Eosauravus:* Part of skeleton, from above. Enlarged. Specimen in National Museum.

Cardiocephalus Broili (Fig. 63).—Middle teeth of maxillae largest. Diameters of orbit nearly equal to distance between orbits and nares. Palate unknown. Pineal foramen small. Skulls and cervical vertebrae. Wichita beds, Texas.

Family **PARIOTICHIDAE** Cope

Small terrestrial reptiles of about a fourth or less of a meter in length, closely allied to the Captorhinidae. Incisor teeth small. Teeth in one or more rows in maxillae and dentaries. Skull more flattened and less elongate than in the Captorhinidae, its structure imperfectly known.

Pariotichus Cope.—Imperfect skull. Palate with a large smooth plate at base of skull. Incisor teeth not enlarged. One or two cheek teeth larger than the others. One or more rows of teeth. Texas.

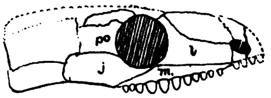

FIG. 63.—*Cardiocephalus:* Skull, from side. Enlarged one-half. No. 1047.

Ectocynodon Cope.—Only fragment of skull known. Skull apparently wider than that of *Pariotichus*, with a different pattern of sculpture (Case).

Isodectes Cope (Fig. 37). Teeth small, equal, acute; apparently in single rows. Orbits large. Vertebrae like those of *Captorhinus*. Skulls, vertebrae. Texas.

Family **CAPTORHINIDAE** Case

Lowland or littoral, invertebrate or flesh-eating reptiles of from a fourth of a meter to one meter in length. Skull elongate, triangular in shape, the face more or less compressed laterally. Pineal foramen small. Dermosupraoccipitals confined to the occipital aspect of skull. No supratemporal bone. Palatine teeth small. Teeth in dentary in one or more rows; in maxillae in two or more. Vertebrae with stout arches and vestigial spines. Two sacral vertebrae. Tail moderately long. Ribs holocephalous, the anterior ones dilated distally. Slender parasternal ribs present. No cleithrum. Mesopodials with ossified centralia and five distalia. Legs more elongate, the claws acuminate.

Captorhinus Cope (Figs. 16, 64).—From a fourth to a third of a meter in length. Four incisor teeth, the anterior ones moderately

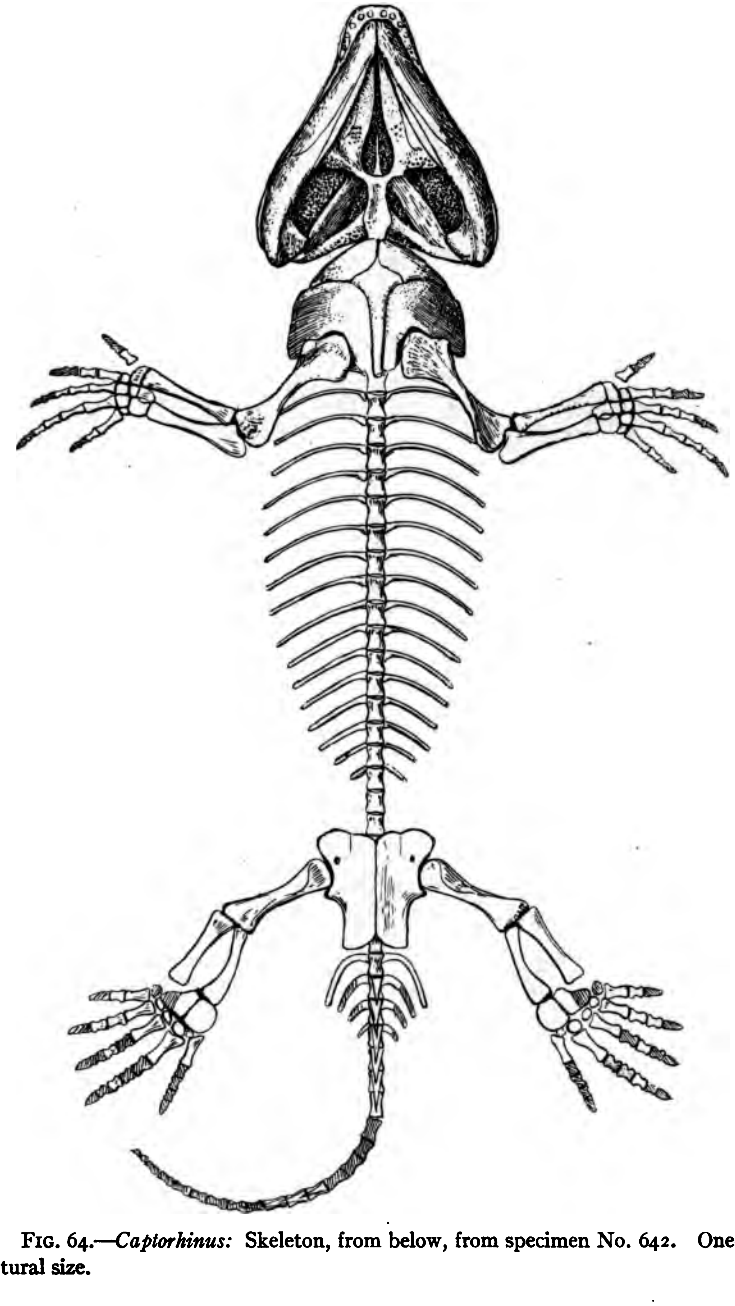

FIG. 64.—*Captorhinus:* Skeleton, from below, from specimen No. 642. One-half natural size.

elongated and recurved. Teeth in dentaries and posterior part of maxillae in two to four rows, low and subconical, the external row decreasing in length from the middle. Skull with small tabular (supratemporal ?). Nearly complete skeletons. Texas; Oklahoma.

Labidosaurus Cope (Figs. 15, 65).—About one meter in length. Face much compressed, beak-like, with long, recurved, and pointed incisor teeth; three in premaxilla. A single row of flattened teeth in dentaries; an inner row on posterior part of maxillae. No tabular. Uppermost Clear Fork, Texas.

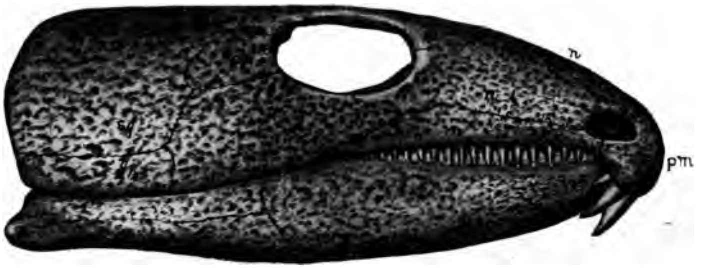

FIG. 65.—*Labidosaurus:* Skull, from the side. One-half natural size

Pleuristion Case.—Vertebrae and humeri of the *Captorhinus* type, all that are known. Oklahoma.

Genera *INCERTAE* Sedis

Chamasaurus Williston.—Very small reptiles, with long, slender mandible, bearing twenty-seven low, flattened, acuminate, nearly isodont teeth. Only mandible known. New Mexico.

Puercosaurus Williston (Fig. 37).—Skull flattened, rather broad, with relatively large orbits. Dermosupraoccipital, if on upper surface of skull, very narrow. A pineal foramen. Teeth in single row in dentaries and maxillae, low and obtusely conical or cylindrical. One or more cheek teeth much larger than others. One or two median mandibular teeth also enlarged. Skulls, only. New Mexico.

Archeria Case.—Reptiles of perhaps a meter or more in length. Humerus with entepicondyle very large, rectangular in shape, reaching to above middle of bone. Humerus only known. Brier Creek bone-bed, Wichita beds, Texas.

Bathyglyptus Case.—One of the largest, if not the largest of known Texas reptiles. Teeth isodont, or subisodont, the anterior ones larger, and cylindrical. Nineteen in mandible. Mandible only known. Texas.

Helodectes Cope.—Indeterminable. Texas.

Genus novum.—Vertebrae like those of *Labidosaurus*, that is, with rudimentary spines, but of the size of *Diadectes*. A series of dorsal and caudal vertebrae only. El Cobre, New Mexico.

Order *THEROMORPHA* Cope

Temporal opening bounded above by the squamosal and postorbital below by jugal. Six or seven cervical vertebrae. Legs more elongate. Neural arches of vertebrae seldom thickened. Septomaxilla, lacrimal, postorbital, quadratojugal, squamosal, and epipterygoid always present. No dermal bones fused in midline. Pineal foramen always present. A separate prearticular in the mandible, the coronoid elongate, and splenial taking part in the symphysis. The pterygoids articulate with prevomers. Teeth

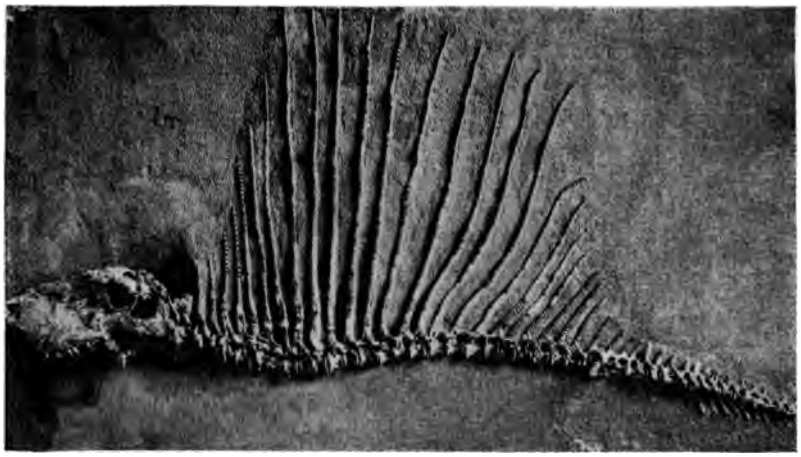

FIG. 66.—*Dimetrodon gigas:* Cranium and vertebral column, as mounted in Walker Museum. One-eighteenth natural size. Restored parts are marked with black lines. No. 1002.

thecodont or protothecodont, attached to premaxillae, maxillae, pterygoids, and palatines, sometimes vomers and coronoids. Ectopterygoid not yet demonstrated. Vertebrae deeply biconcave or notochordal. All vertebrae to pygals with intercentra.

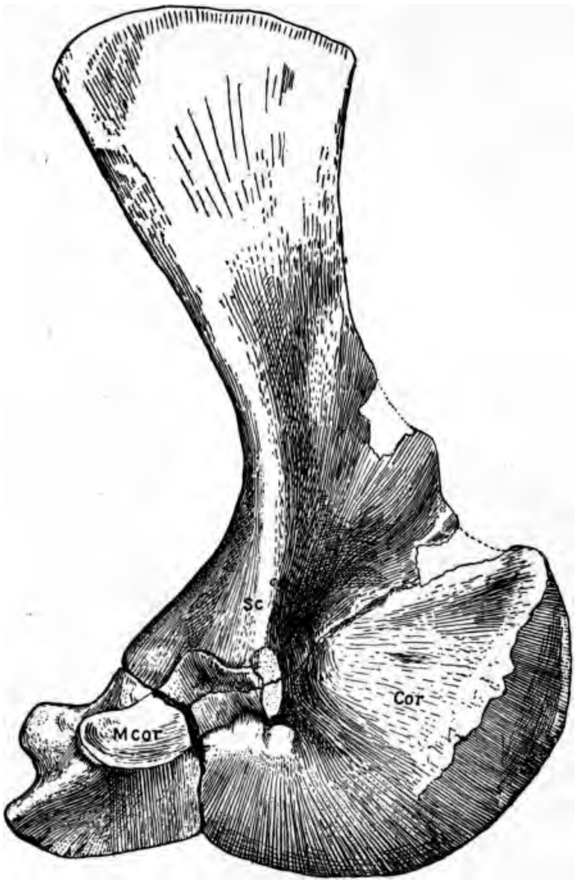

FIG. 67.—*Dimetrodon:* Right scapula (*Sc*), coracoid (*Cor*), and metacoracoid (*Mcor*), from without. One-third natural size. No. 661, Peabody Museum.

Proatlas present, articulating with exoccipitals and atlas. Atlas composed of a large, free odontoid, supported the arch chiefly, and an intercentrum not much larger than the following one. Capitulum of ribs articulating intercentrally, the tubercle to diapophysis. Clavicles and interclavicle present, never rugose. No sternum. Coracoid, metacoracoid, and scapula fused in maturity; a supraglenoid and a supracoracoid foramen. Pubis and ischium more or less plate-like, usually with a small median ischio-pubic vacuity. Acetabulum imperforate. Radiale, intermedium, ulnare, pisiform, centralia, and five carpalia always present. Tarsus with six to nine bones; centrale and fifth tarsale rarely unossified. Phalangeal formula, 2, 3, 4, 5, 3 (4).

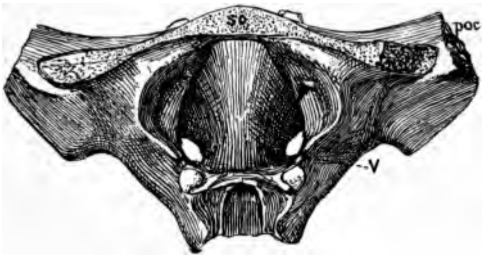

FIG. 68.—*Dimetrodon:* Occipital complex, with brain-case, from above. One-half natural size.

Family **SPHENACODONTIDAE** Marsh (**CLEPSYDROPIDAE** Cope)

Carnivorous, terrestrial reptiles of from one to three meters in length. Skull high and narrow. Teeth flattened-conical, with cutting edges; dentition anisodont, with a diastema between maxilla and premaxilla. Dermosupraoccipitals, tabulars, and supratemporals probably all present. Mandible with an emargination on the posterior inferior border. Dorsal spines elongate. Twenty-seven presacral and three sacral vertebrae present. Ribs dichocephalous, none expanded distally. Pubis with the upper margin extended and thickened. Eleven carpal and eight tarsal bones. Ungual phalanges curved and acuminate.

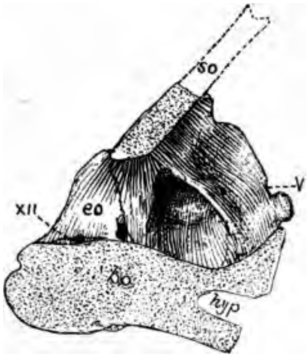

FIG. 69.—*Dimetrodon:* Section through brain cavity. One-half natural size.

Dimetrodon Cope (Figs. 13, 14, 66–70).—Spines of dorsal vertebrae very long, from ten to twenty-five times the height of centra, acuminate. Teeth with crenulate edges. Length of tail unknown. Numerous specimens, Wichita beds and Clear Fork, Texas; Oklahoma.

Sphenacodon Marsh (Fig. 71).—Spines of dorsal vertebrae flattened distally, not more than six times the height of centra. Fewer teeth, their edges not crenulate. Imperfect skulls, limb bones, and vertebrae. New Mexico.

Clepsydrops Cope.—Spines less elongate than in *Dimetrodon*. Tail long. Articular ends of bones poorly ossified. Vertebrae, fragmentary skull, and various limb bones. Illinois; Texas.

? *Tetraceratops* Matthew.—Skull narrow, high, about 10 dm. in length, with two pairs of rugosities for horns, over prefrontals and nasals. Teeth similar to those of *Dimetrodon* with long diastema. Only skull known. Location in this family doubtful. Texas.

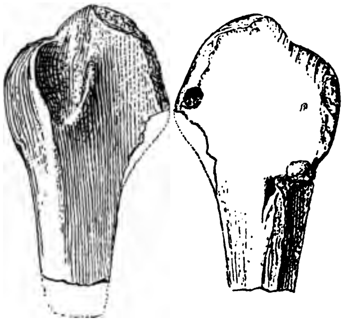

FIG. 70.—*Dimetrodon:* Tympanic(?) bone, from above and below. Natural size.

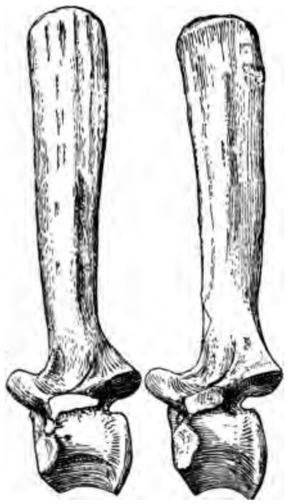

FIG. 71.—*Sphenacodon:* Dorsal vertebrae. Two-fifths natural size.

Family **POLIOSAURIDAE** Case

Insectivorous or carnivorous reptiles from one to one and a half meters in length. Skull elongate, not broad, not elevated. Teeth small, conical, not markedly anisodont, without diastema. Dermosupraoccipitals broad (tabulars, supratemporals?). Twenty-seven presacral, two sacral, vertebrae. Tail long. Pubis with thickened and elongate upper border. Spines of vertebrae flattened or cylindrical not more than three times the height of centra. No cleithrum. All ribs slender. Slender parasternals present. Claws acuminate.

Varanops Williston (Fig. 72).—Teeth slender, conical, about thirty in each maxilla. Fifth distale and first centrale in tarsus

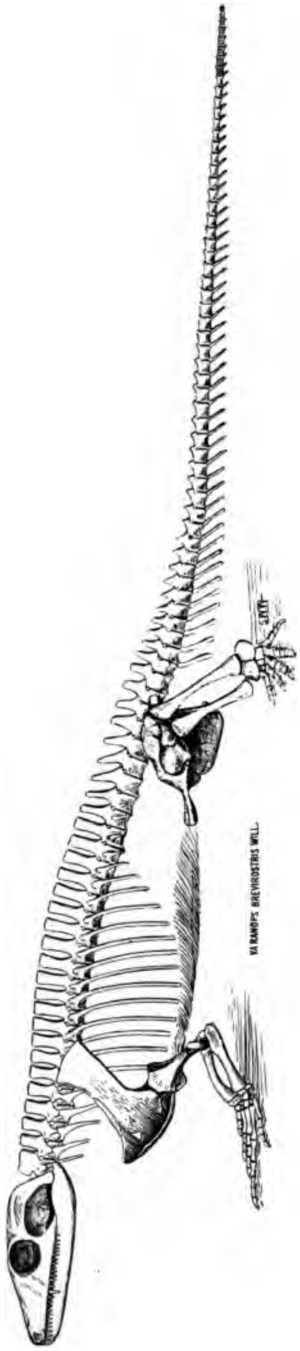

FIG. 72.—*Varanops*: Skeleton, about one-sixth natural size. From mounted specimen in Walker Museum. No. 644

unossified. Metacoracoid unossified. Ribs dichocephalous. Several complete skeletons. Clear Fork, Texas.

Varanosaurus Broili.—Skull more elongate. About fifty conical teeth in each maxilla. Metacoracoid ossified. Ribs (in part, at least) holocephalous. Skull, vertebrae, and various limb bones. Clear Fork, Texas.

Poliosaurus Case.—About thirty teeth in each maxilla, conical. Vertebrae with free neural arches. Associated limb bones poorly ossified at ends: possibly immature specimens. Texas.

Pœcilospondylus Case.—Teeth slender, conical. Dorsal vertebrae with expanded neural arches. Fragments of skull and the nearly complete series of vertebrae. Texas.

Arribasaurus Williston (Fig. 11). —Teeth conical. Carpus with two ossified centralia and five tarsalia. Fragments of jaws, vertebrae, and limb bones. New Mexico.

? *Scoliomus* Williston and Case. —Larger, limb bones slender. Humerus with planes of extremities divergent beyond a right angle. Limb bones and centra. New Mexico.

Family **OPHIACODONTIDAE**
Williston and Case

Littoral or lowland reptiles about two meters in length, insectivorous or carnivorous in habit. Skull long, high, and very narrow, the small orbits situated far back. No diastema. Temporal foramina small. Twenty-seven presacral and two sacral vertebrae; tail long. Dorsal spines flattened, less than four times the height of centra. Ribs holocephalous, the anterior ones dilated distally. Slender parasternal ribs. Legs rather short and stout. Ungual phalanges stout. Upper border of pubis thickened. Two centralia pedis. Figs. 73–78.

Ophiacodon Marsh.—Teeth slender, conical, recurved, and pointed, about thirty-six in each maxilla. A small, upper temporal foramen; the normal vacuity small. Nearly complete skeleton. Details of skull unknown. New Mexico.

Theropleura (*Diopaeus*) Cope (Figs. 33–35).—Teeth apparently more flattened. Most of skeleton known except details of skull, the feet, and tail. Doubtfully distinct from foregoing. Lower Clear Fork or Wichita beds, Texas.

Genus novum? (Fig. 36).—Maxillae and dentaries long, campylognathous, with flattened, cutting, anisodont teeth. Other parts of skeleton unknown unless the humerus shown in Fig. 84 belongs here. Craddock bone-bed, Texas.

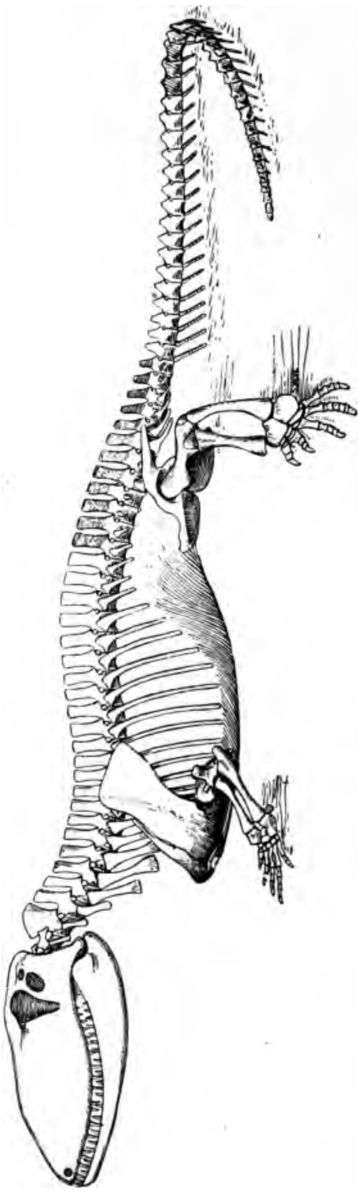

FIG. 73.—*Ophiacodon:* Skeleton, from mounted specimen in Walker Museum. About one-twelfth natural size. No. 671

Family **CASEIDAE** Williston

Invertebrate or plant-eating reptiles about one meter in length. Skull short, broad, and high, with elevated nasal region and large nares; rugose. Mandibular and maxillary teeth about eleven in number on each side, obtusely oval, conical, not anisodont. Palate and coronoids densely covered with small, conical teeth. Pineal foramen large. Dermosupraoccipitals and tabulars present (supratemporals?). Twenty-five presacral and three sacral vertebrae; tail long. Spines flattened or cylindrical, not higher than centra. Abdomen large. Probably no ossified parasternal ribs. Dorsal ribs dichocephalous, stout, and long; none expanded distally.

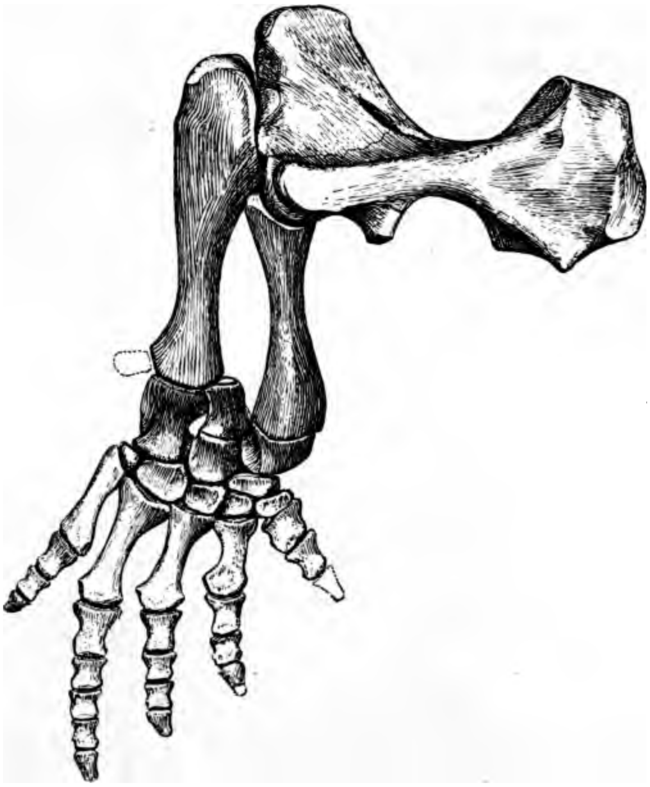

FIG. 74.—*Ophiacondon:* Anterior extremity, as mounted. One-half natural size. No. 671.

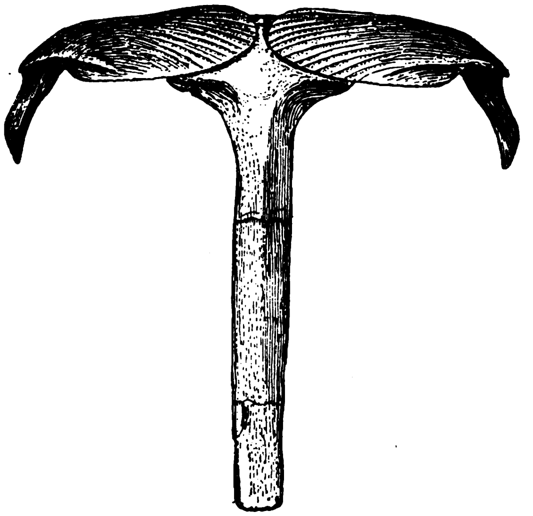

Fig. 75.—*Ophiacodon:* Interclavicle and clavicles. One-half natural size. No. 671.

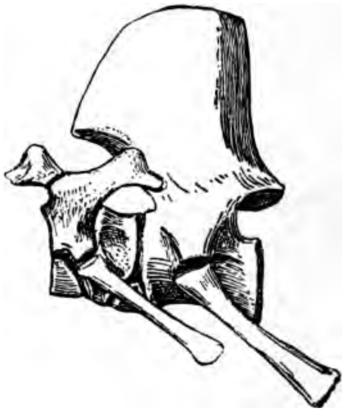

Fig. 76.—*Ophiacodon:* Proatlas, axis, and ribs. Two-thirds natural size. No. 671.

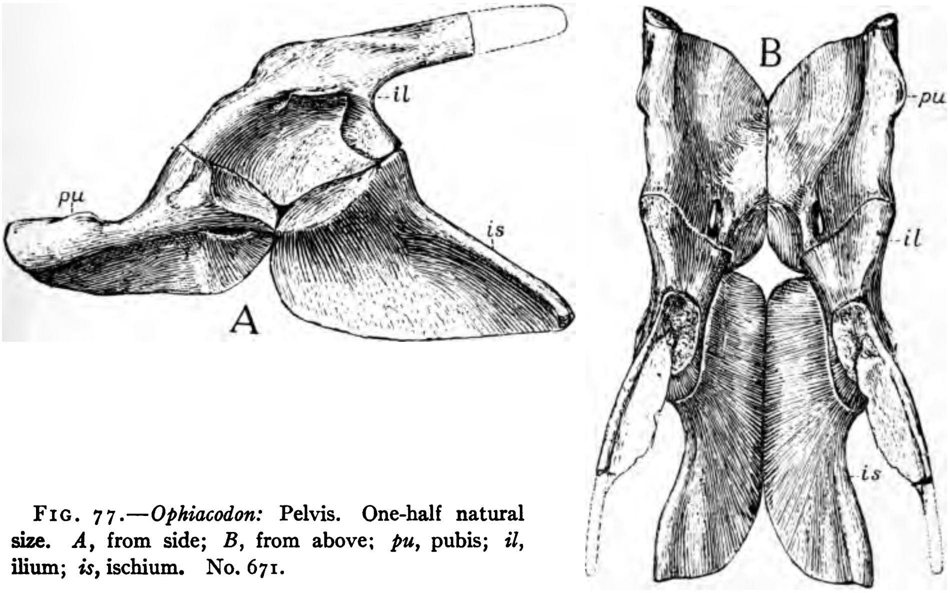

Fig. 77.—*Ophiacodon:* Pelvis. One-half natural size. *A*, from side; *B*, from above; *pu*, pubis; *il*, ilium; *is*, ischium. No. 671.

Front legs relatively long and stout. Carpus fully ossified. Claws curved and acuminate. Pubes short and broad.

Casea Williston (Figs. 9, 10, 79).—Ilium helmet-shaped, projecting in front of acetabulum. Several complete skeletons. Clear Fork, Texas.

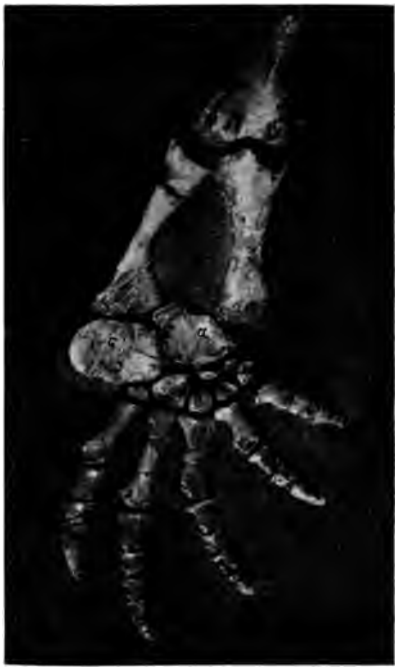

FIG. 78.—*Ophiacodon:* Right hind leg, from mounted skeleton. A little less than one-third natural size. *a*, astragalus; *c*, calcaneum. No. 671.

? *Trichasaurus* (*Trispondylus*) Williston.—Ilium not helmet-shaped, with a post-acetabular process. Only vertebrae, pelvic girdle, and limb and foot bones known. Clear Fork, Texas.

Family **EDAPHOSAURIDAE** Cope

Subaquatic or terrestrial, invertebrate eating reptiles, two or three meters in length. Skull short, high, and narrow, relatively small. Teeth of maxillae and dentaries concave and slightly rugose on inner sides, nearly isodont, in single rows. Palate and coronoids with numerous, conical teeth. Details of skull-structure imperfectly known. Temporal vacuity large. Dorsal vertebrae with very long spines, from ten to twenty times the height of centra, each spine bearing more or less elongated transverse processes. Ribs dichocephalous. Two sacral vertebrae; tail of considerable length. Scapula with cleithrum. Humerus with both ent- and ectepicondylar foramina. Epipodials relatively short. Feet unknown.

Edaphosaurus Cope (Figs. 80, 81).—Cervical spines slender, pointed. Wichita beds, Texas; New Mexico; Dunkard beds, Ohio (*Naosaurus?*); Rothliegendes, Germany, Russia (*Naôsaurus?*).

Naosaurus[1] Cope.—Spines of cervical vertebrae with the distal extremities much flattened and expanded. Only vertebrae and some girdle bones known. Clear Fork, Texas (Ohio? Germany?).

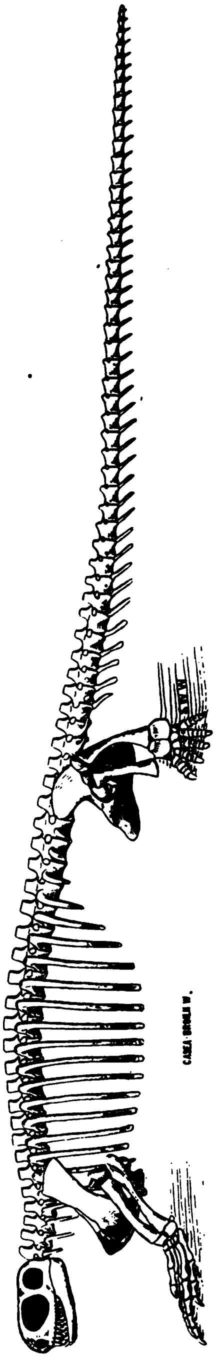

FIG. 79.—*Casea:* Skeleton, about one-sixth natural size. From mounted specimen in Walker Museum. No. 565

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[1] Cope originally based the genus *Naosaurus* on three species, *cruciger*, *claviger*, and *microdus*, the last first described as *Edaphosaurus*, without specifying either as the genotype. Case later selected *cruciger* as the type of *Naosaurus*. Whether *cruciger* has the cervical spines dilated or not cannot be said. If it should turn out that the spines of this species are all slender at their extremities, the stickler for nomenclatural laws may insist that the name *Naosaurus* becomes a synonym of *Edaphosaurus*, and that a new name should be chosen for the genus of which the species *claviger* may be taken as the type. Inasmuch as the type specimen of *cruciger* came from the Clear Fork beds the probability is that its spines are dilated. I think that the name *Naosaurus* should be retained, the more so as it is at present one of the best known of all those of the American Permian reptiles.

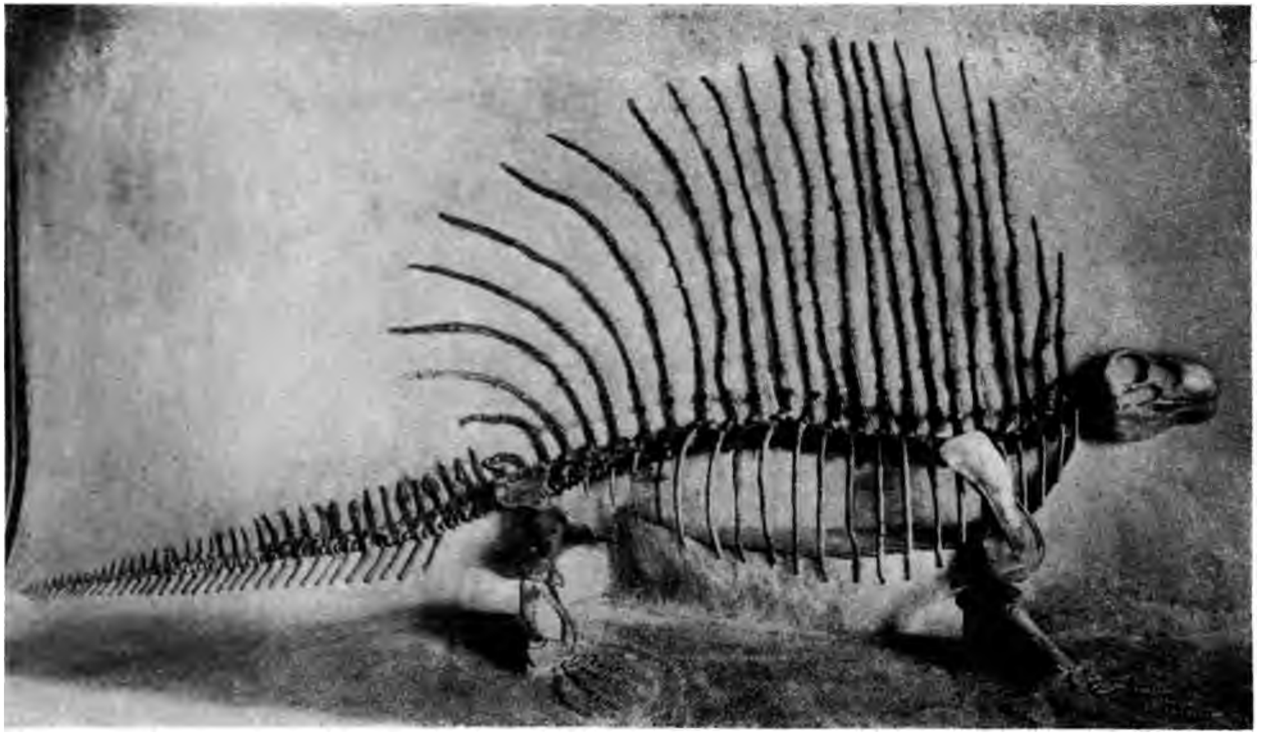

FIG. 80.—*Edaphosaurus:* Skeleton, as mounted by P. C. Miller, under the author's direction, in Walker Museum. One-twelfth natural size. The different parts of the skeleton were found more or less commingled in the Brier Creek bone-bed. The distal part of the tail and the feet are restored from allied animals; the former is probably too short. The skull is modeled from a perfect specimen and is a trifle too large. No. 703.

Genera *INCERTAE* Sedis

Mycterosaurus Williston (Figs. 82, 83).—Skull elongate and narrow. Orbits large. Large dermosupraoccipitals. Teeth flattened and obtusely pointed. Vertebrae with short flat spines. Coracoids well ossified. Differs from the Poliosauridae chiefly in the teeth. Limbs, most of girdles and of vertebral column unknown. Lower Clear Fork, Texas.

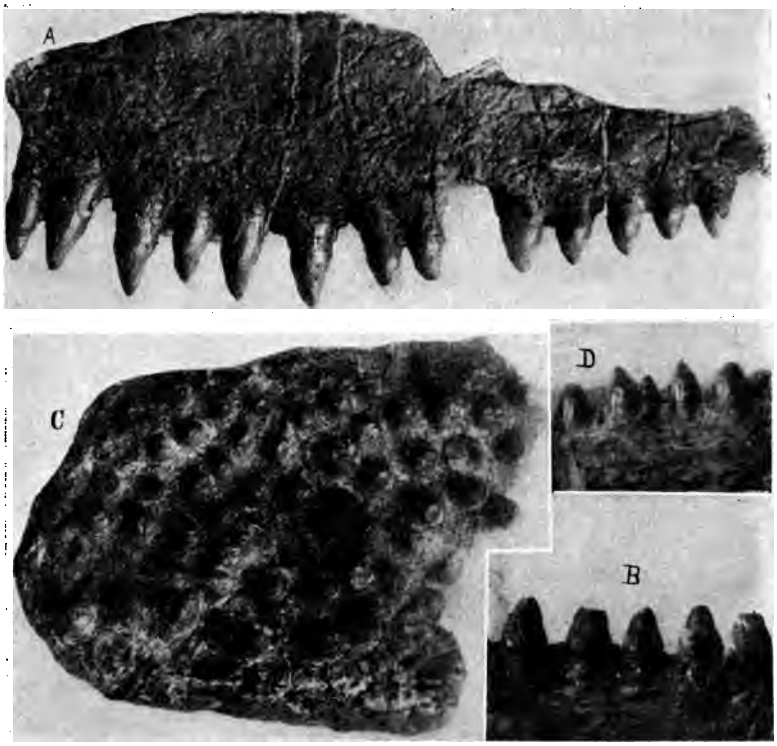

FIG. 81.—*Edaphosaurus*: *A*, left maxilla, outer side; *B*, mandibular teeth, inner side; *C*, palatine teeth, from below; *D*, palatine teeth, from the side. All enlarged nearly twice. Specimens from the Brier Creek bone-bed, Texas, associated with the skeleton shown in Fig. 80.

Glaucosaurus Williston.—Skull very short, narrow, and high, with very large orbits. Each maxilla with fifteen small, obtusely pointed teeth of nearly equal size. Only the skull known. Differs from the Poliosauridae chiefly in the short, high skull and less conical teeth. From the same horizon and locality as the last.

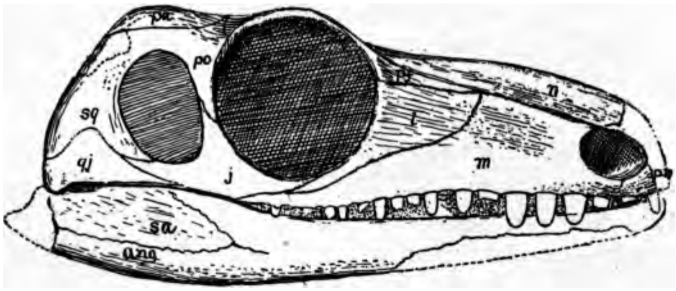

FIG. 82.—*Mycterosaurus:* Skull, from side. Natural size. No. 692

Scoliomus Williston and Case.—Perhaps two meters in length. Limb bones slender. Humerus with planes of extremities divergent beyond a right angle. Only limb bones and vertebral centra known. New Mexico.

Tetraceratops Matthew.—See Sphenacodontidae.

Tomicosaurus Case.—Very small reptiles. Vertebrae about one-fourth of an inch in length, with slender arches and short spines. Mandible slender, with small, rather flattened, not crenulate teeth. Only vertebrae and anterior end of mandible known. Texas.

Metamosaurus Cope.—Vertebrae 21 mm. in length and 30 mm. in breadth. "The anterior zygapophyses have a peculiar form, their articular faces being directed downward and outward" (Cope). Imperfect vertebrae only. Texas.

Embolophorus Cope.—Two imperfect vertebrae of small size. Length of centrum 5 mm., width less than 4 mm. Ribs double-headed. Indeterminable. Texas.

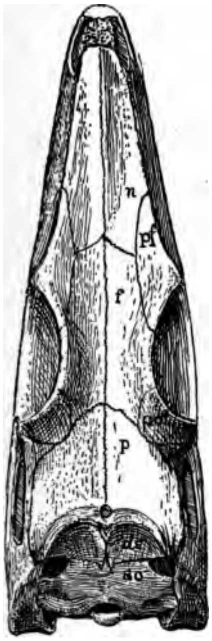

FIG. 83.—*Mycterosaurus:* Skull, from above. Natural size. No. 692.

Archaeobolis Cope.—Fragments of jaw only. Teeth conical, dentition anisodont. Fifteen teeth in space of 15 mm. Illinois.

Bathygnathus Leidy.—Left incomplete maxilla with crenulated, cutting teeth like those of ***Dimetrodon***. Probably a member of the Sphenacodontidae. Prince Edward Island, Canada.

Genus novum? (Fig. 84).—Craddock bone-bed (see Ophiacodontidae). Clear Fork, Texas.

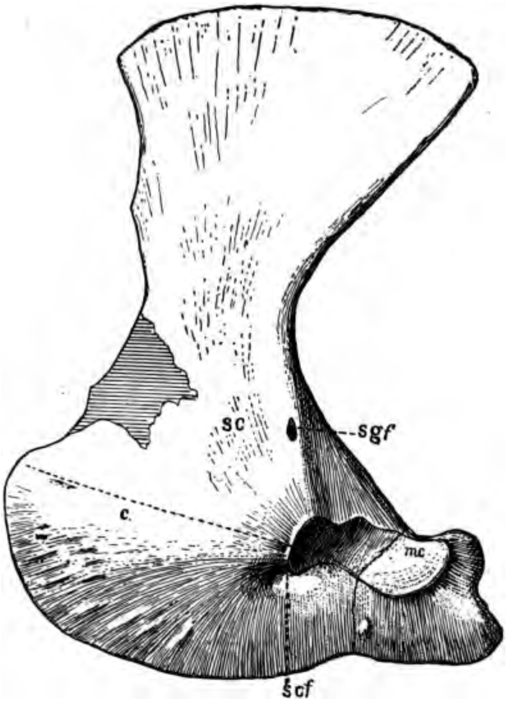

FIG. 84.—*Genus novum:* Left scapula, from without. Two-fifths natural size. *sc*, scapula; *c*, coracoid; *mc*, metacoracoid; *sgf*, supraglenoid foramen; *scf*, supracoracoid foramen. Craddock bone-bed. No. 1316.

Order *SQUAMATA* (?)

Suborder ARAEOSCELIDIA Williston

(? Protorosauria)

Temporal region covered by broad squamosal, the quadrate fixed. The single temporal opening bounded below by postorbital and squamosal: above by parietal, behind by tabular. Teeth on vomers and transverse.

Family **ARAEOSCELIDAE** Williston

Very slender climbing reptiles about a half-meter in length. A pineal foramen. Lacrimals small or vestigial. Teeth small, flattened, obtuse. Dermosupraoccipitals possibly present. Small teeth on vomers, transverse, palatines and pterygoids. Cervical vertebrae elongate, seven or more in number. About twenty-seven presacrals and two sacrals; spines vestigial. Cervical ribs slender, single-headed, attached to anterior part of centra; dorsal ribs double-headed, attached to arch and centrum. No ventral ribs. Intercentra present to chevrons. Pelvis plate-like, without median vacuity. Limb bones very long and slender, hollow. Humerus with both ent- and ectepicondylar foramina.

Araeoscelis Williston (Figs. 1–8).—Nearly all of the skeleton. Clear Fork, Texas.

CONTRIBUTIONS FROM WALKER MUSEUM
VOLUME I. NO. 1

THE VERTEBRATES FROM THE PERMIAN BONE BED OF VERMILION COUNTY, ILLINOIS

BY

E. C. CASE

CHICAGO
The University of Chicago Press
JANUARY, 1901

described by Cope are now missing from the collection, and so cannot be figured.

Several specimens are preserved in the collection which were never described by Cope. I have refrained from giving new names to these, as it is altogether probable that the seemingly new forms are but portions of the skeleton of animals that have been named from other parts of the skeleton. The numbers given at the close of each description, are the record numbers of the Paleontological collection in Walker Museum, at the University of Chicago.

Janassa strigilina Cope. Plate I, Figs. 1*a*, 1*b*, 1*c*.

Strigilina linguæformis Cope, 1877, Proc. Am. Phil. Soc., p. 53. (Specific name preoccupied in 1868 by Atthey.)

Janassa strigilina Cope, 1881, Am. Nat., p. 163.

Janassa strigilina Woodward, 1889, Cat. Foss. Fishes Brit. Mus., Pt. I, p. 38.

Generic characters: "The tooth is a flat, osseous plate, whose outline is pyriform, the wider end recurved in one direction as the transverse cutting edge; the other extremity narrowed and recurved in the opposite direction as the root. The side from which the cutting edge arises is crossed by numerous plicæ from the base of the root to near the base of the cutting edge; the opposite side is smooth."

Specific characters: "The plicate surface terminates behind in a median angle, at the base of the root. There are eight plicæ which all cross the plane, excepting the sixth, which is interrupted in the middle by the strong angulation of the seventh, which touches the fifth. The lateral extremities of the right are in contact with the base of the recurved cutting portion. The latter is convex transversely, leaving a smooth surface between it and the eighth plica. The smooth side of the tooth is shining, and there is a shallow fold, which passes around its side and crosses just at the base of the recurved cutting lamina."

MEASUREMENTS.

"Total length of the plane - - - - - -	.008 m
Width at base of the cutting lamina - - -	.006
Width at the base of the root - - - - -	.004
Thickness of plane portion - - - - -	.0015 "

[No. 6500.]

Janassa gurleyana Cope. Plate I, Figs. *2a*, *2b*, *2c*.

Strigilina gurleiana Cope, 1877, Proc. Am. Phil. Soc., p. 191. (Pal. Bull., No. 26.)

Janassa gurleiana Cope, 1881, Am. Nat., p. 163.

Janassa gurleiana Woodward, 1889, Cat. Foss. Fishes Brit. Mus., Pt. I, p. 39.

"The tooth is quite small, its length only equaling the width of the known tooth of *S.* (*Janassa*) *linguæformis.* It is also narrower in proportion to the length. The root and the cutting edge are turned in opposite directions as in the other species. The principal difference between the two is seen in the character of the transverse ridges or crests of the oval face. There are two crests less, or five, with a delicate basal fold, making six, while, counting the fold, there are eight in *S.* (*Janassa*) *linguæformis.* The anterior ridge is transverse; the others slightly convex backwards, and all are equidistant and uninterrupted, which is not the case in the older species. They are also of different form, being distinct ridges with anterior and posterior faces similar. In *S.* (*Janassa*) *linguæformis* the anterior face only is vertical, the posterior descending very gradually, the whole forming a series of steps.

"Length of the ridged face, .0060^{m}; width anteriorly, .0035^{m}; width posteriorly, .0020^{m}."

[No. 6501.]

Pleuracanthus (**Orthacanthus**) **quadriseriatus** Cope. Plate I, Figs, *3a*, *3b*.

Orthacanthus quadriseriatus Cope, 1877, Proc. Am. Phil. Soc., p. 192. (Pal. Bull., No. 26.)

Pleuracanthus quadriseriatus Woodward, 1889, Cat. Foss. Fishes Brit. Mus., Pt. I, p. 9.

Represented in the collection by imperfect radial spines. Both Newberry and Cope remark that it is very likely that the spines called *Orthacanthus* may belong to the the same fish as the teeth called *Didymodus* (*Diplodus*), and as the teeth are distinctly referable to the genus *Pleuracanthus Ag.*, it is perhaps best to follow Zittel in regarding all three names as synonyms of *Pleuracanthus.* The teeth and spines are found in close connection. The species here described differs from the *O. gracilis* of Newberry in having the denticles shorter. The description given by Cope is as follows: "The spine is wider than deep, and the series of denticles are widely separated. The surface between them is gently convex and smooth. The anterior face is strongly convex, and presents at each side two shallow furrows. The external groove is divided by a series of thin longitudinal denticles which are smaller than those of the principal row, and which are sometimes confluent at the base. The principal denticles are closely placed, stout, acute, and recurved.

"Transverse diameter of shaft .0035^{m}; antero-posterior diameter .0025^{m}; the portion of the shaft preserved is straight."

It is noticeable that the denticles of the outer row become confluent in a low ridge on the lower portion of the spine.

[No. 6502.]

Pleuracanthus (Orthacanthus) gracilis Newb. Plate I, Fig. 4.

Orthacanthus gracilis Newb., Geol. Surv. Ohio, Pal., Vol. II, p. 56. Plate LIX, Fig. 7.

Orthacanthus gracilis Newb., Cope, 1881, Am. Nat., p. 163.

"Spine small and straight, about three inches long, very slender and acute; section circular at base, posterior face and sides flattened above, the angle inclosed by them set with acute, recurved, compressed denticles throughout the upper two thirds of the entire length; surface smooth or finely striate longitudinally."

The name *Orthacanthus* was used by Newberry only provisionally for spines which were supposed to belong with teeth called *Diplodus*, and was to be suppressed when the two should be found together.

It is noticeable that the denticles are fewer and larger than those on the spine of *P. quadriseriatus*, and that there is but a single row of denticles on each side.

[No. 6503.]

Pleuracanthus (Didymodus) compressus Newb. Plate I, Figs. 5*a*, 5*b*, 5*c*, 5*d*.

Diplodus (?) *compressus* Newb., Cope, 1877, Proc. Am. Phil. Soc., p. 54.

Didymodus (?) *compressus* Newb., Cope, 1883, Proc. Phil. Acad. Nat. Sc., p. 108.

Represented in the collection by several imperfect teeth. Cope offered no additional description of the form, contenting himself with the statement that "one with a lateral and median denticles nearly complete, agrees pretty well with the species cited." In 1883 he substituted the name *Didymodus*, as the name *Diplodus* was preoccupied, having been used by Rafinesque for a genus of fishes.

The teeth are much smaller than the species of the same genus found in Texas.

Later several complete crania of the genus were obtained from Texas and described in detail by Professor Cope, Trans. Am. Phil. Soc., 1884, pp. 572–590, 1 plate (Pal. Bull., No. 38). In the American Naturalist of the same year, p. 413, the genus was made the type form of the new order *Ichthyotomi* of the *Elasmobranchii.*

The form is now quite usually recognized as belonging to the genus *Pleuracanthus* Ag., one of the common forms of the Carboniferous and Permian faunas of Europe and America.

[No. 6504.]

Thoracodus emydinus Cope.

> *Thoracodus emydinus* Cope, 1883, Proc. Acad. Nat. Sc., Phil., p. 108.
>
> *Thoracodus emydinus* Woodward 1889, Cat. Foss. Fishes Brit. Mus., Pt. I, p. 39.

"The form of the tooth or jaw on which this genus is proposed, reminds one of that of a *Diodon*, and also of one half of that of a *Janassa*. It appears to be the half of a bilateral plate, which is divided on the middle line by suture. Its form is somewhat that of the anterior part of an episternal bone of a tortoise. It consists essentially of a smooth border, separated from the remainder of the tooth by a transverse groove. The interior portion is, on the superior face (if the piece belong to the inferior jaw, and *vice versa*), transversely ridged and grooved, after the manner of the genus *Janassa*."

Specific characters: "The smooth border is wide above and below. Its edge is produced into a median projection, which is decurved. On the inferior surface it is marked by shallow grooves, which radiate from the groove which bounds it posteriorly, extending nearly to the free edge. Posterior to the bounding groove, the surface is smooth. The posterior surface above has its grooves concentric with the curved free margin. The ridges are narrow, and step-like in position, presenting their free edges backwards. There are no grooves other than these steps. They have an angular curve opposite to the angle of the free margin, and at the angle the groove which separates them is narrowed, while it widens at other points. Free edge of border thickened; surface everywhere smooth."

MEASUREMENTS.

"Length of fragment transversely	.014^{m}
Length of fragment antero-posteriorly	.011
Width of border area at median suture	.005
Seven cross ridges	.005
Thickness at suture at cross ridges	.002 "

[This specimen is missing from the collection.]

Sagenodus vinslovii Cope. Plate I, Figs. 6*a*, 6*b*.

Ceratodus vinslovii Cope, 1875, Proc. Phil. Acad. Nat. Sc., p. 410.

Ceratodus vinslovii Cope, 1877, Proc. Am. Phil. Soc., p. 54.

Ptyonodus vinslovii Cope, 1877, Proc. Am. Phil. Soc., p. 192. (Pal. Bull., No. 26.)

Sagenodus vinslovii Woodward, 1891, Cat. Foss. Fishes Brit. Mus., Pt. II, p. 262.

Sagenodus vinslovii Williston, 1899, Kans., Univ. Quart., Series A, p. 176.

"The crown of the tooth is in general outline an oval, wider at one end than the other, the inner border gently convex and entire. The outer border is marked by six shallow notches which are separated by as many sharp, compressed projections. The emarginations and denticles are the termini of corresponding grooves and ridges, which radiate from a smooth space along the inner margin of the crown. From this plane the grooves gradually deepen to the margin; the separating ridges are acute and without irregularity or serration. The base or root of the tooth is quite wide. Externally it extends beyond the border of the crown at the notches, and has projections corresponding to the denticles, from which it is separated by a horizontal notch. On the inner side the base extends like a shelf beyond the posterior half of the crown, and is produced backwards beyond its posterior border. The inferior plane is concave in transverse section; the crown is plane in all directions."

MEASUREMENTS.

"Length of crown preserved	.021^{m}
Width crown	.013
Length of root preserved	.022
Depth of root internally	.005
Depth of root externally	.003 "

"This *Ceratodus* (*Ptyonodus*) resembles the species described by Agassiz under the name of *C. parvus* and *C. serratus* from the English Trias, but differs from them in the shortness of the tooth-like processes. In none of the species do I find such a development of the basis on the inner side."

[No. 6507.]

Sagenodus vabasensis Cope. Plate I, Fig. 7.

Ctenodus vabasensis Cope, 1883, Proc. Phil. Acad. Nat. Sc., p. 110.

Sagenodus vabasensis Woodward, 1891, Cat. Foss. Fishes Brit. Mus., Pt. II, p. 261.

Sagenodus vabasensis Williston, 1899, Kans. Univ. Quart., Series A, p. 176.

"This fine species is represented by an almost perfect tooth. It is allied to the *C. fossatus* Cope, but is wider, and the crests do not radiate so equally, but are chiefly directed in one direction, as in most species of the genus. The *C. gurleianus* and *C. pusillus* are at once distinguished by the small number of crests, while the *C. periprion* and *C. dialophus* have a larger number of crests, and are otherwise different. *C. porrectus* differs less from it, but has only five $\frac{1}{1}$ crests, while *C. vabasensis* has six $\frac{1}{1}$. The $\frac{1}{1}$ represents the small posterior (?) crest, which is double. This, with the next one, is directed slightly posteriorly; the fifth is at right angles to the long axis, and the anterior four extend more or less forwards. They are serrate nearly to their bases, but the teeth are obsolete on their basal halves. The straight part of the internal edge extends as far forwards as the fourth crest, and is continued posteriorly as a short process. No fossæ at ends of crests. Superior face of tooth wide and slightly concave. The anterior part of the first and second crests are broken away, so that it is impossible to say whether they are produced as in *C. porrectus*."

MEASUREMENTS.

" Length to marginal base of second crest	.024^{m}
Width at marginal base of second crest	009
Width at fourth crest, inclusive of apex	.015
Width of posterior side	.010
Thickness at base of fifth crest	.005 "

[No. 6510.]

Sagenodus gurleyanus Cope. Plate I, Figs. 8*a*, 8*b*, 8*c*

Ctenodus gurleyanus Cope, 1877, Proc. Am. Phil. Soc., p. 55.

Sagenodus gurleyanus Woodward, 1891, Cat. Foss. Fishes Brit. Mus., Pt. II, p. 261.

Sagenodus gurleyanus Williston, 1899, Kans. Univ. Quart., Series A, p. 176.

"This species is indicated by a portion of a tooth, which leaves the number of the ridges a matter of uncertainty. On this account its description might have been postponed, but that the distinctness of its characters render it clear that it cannot be placed with any other species. The crown, as in *Ceratodus* (*Sagenodus*) *paucicristatus*, is narrow and rather thick; but three crests are present, all radiating in the same general direction, the longer close to the inner border. There was not more than one additional crest, or one and a rudiment, and these have probably the same direction as those which are preserved. The crests are sharp, elevated, and coarsely dentate; they are not decurved at the extremity, but cease abruptly with a projecting denticle, beneath which the basis is excavated by a shallow fossa. The inferior face is slightly concave, the internal wall vertical."

MEASUREMENTS.

"Greatest width	.008^{m}
Depth at inner border	.005 "

[No. 6509.]

Sagenodus pusillus Cope. Plate I, Figs. 9*a*, 9*b*.

Ctenodus pusillus Cope, 1877, Proc. Am. Phil. Soc., p. 191. (Pal. Bull., No. 26.)

Sagenodus pusillus Woodward, 1891, Cat. Foss. Fishes Brit. Mus., Pt. II, p. 261.

Sagenodus pusillus Williston, Kans. Univ. Quart., Series A, p. 176.

"Form narrow, the width of the base about equal to the depth. The coronal portion is narrower than the base, because the inner face is oblique, forming an acute angle with the inferior plane. There are but four crests, of which the two longer are directed in one direction, and the two shorter in another. The interior ones of both pairs form a continuous crest which is convex inwards. The crests are straight, elevated and acute; each one supports two or three denticles, which are rectangular and little elevated. The longer ones project beyond the general outline; the shorter ones are less prominent at the extremities; all are obtuse in the vertical direction. The superior surface is smooth. The inferior is slightly concave in the transverse sense. The tooth on which this species is founded is the smallest yet obtained from the formation (Permian of Illinois). Length, .007^{m}; width, .003^{m}; depth at the inner crest, .003^{m}."

[No. 6508.]

Sagenodus fossatus Cope. Plate I, Figs. 10*a*, 10*b*.

Ctenodus fossatus Cope, 1877, Proc. Am. Phil. Soc., p. 54.

Sagenodus fossatus Woodward, 1891, Cat. Foss. Fishes Brit. Mus., Pt. II, p. 261.

Sagenodus fossatus Williston, 1899, Kans. Univ. Quart., Series A, p. 176.

"Represented by a nearly perfect tooth of a general narrow and vertically thickened form. There are five crests, the largest three extended in one direction, and the other two in the other. Between the last of the latter and the inner border is a rudiment of another in the form of a rugosity. None of the crests touch each other at their bases. At their extremities they curve rather abruptly downward, and do not project beyond the inferior plane, from which each one is separated by a deep fossa, whose mouth is a notch in its base. The crests are coarsely dentate, there being three or four teeth on each, and the grooves between them are marked by coarse transverse undulating grooves. The inner border is a deep vertical plane; the inferior face is narrow and concave in transverse section."

MEASUREMENTS.

"Total length - - - - - - - -	.022^{m}
Greatest width - - - - - - -	.007
Depth at middle - - - - - - -	.006 "

"It differs from the *C. serratus* of Newberry in its narrow form, small number of ridges and the very slight prolongation of their extremities."

[No. 6506.]

Sagenodus heterolophus Cope.

Ctenodus heterolophus Cope, 1883, Proc. Acad. Nat. Sc., Phil., p. 109.

Sagenodus heterolophus Woodward, 1891, Cat. Foss. Fishes Brit. Mus., Pt. II, p. 261.

Sagenodus heterolophus Williston, 1899, Kans. Univ. Quart. Series A, p. 176.

"This species is represented by a single broken tooth, which presents remarkable characters. It had apparently, when perfect, but three crests, which differ greatly in length, diminishing very rapidly from the first or marginal crest.

"The crest just mentioned is not only longer, but *much more* elevated than the others, except at the base, where the second crest is the highest. But while the first rapidly rises, the second retains its elevation, and then descends, forming a convex edge, of which the distal part is obtusely serrate. The proximal part of the first crest is worn by friction with the opposing edge of the opposite jaw into a sharp edge, below which its base is covered by a thin layer of the shining cementum which invests the teeth and sides of the second crest. The amount of this shinning layer is thus more extensive than in any other species of *Ctenodus* known to me. The third crest, judging by its base of continuity with the second, is very small."

MEASUREMENTS.

"Elevation of first crest at middle - -	.0095^{m}
Elevation of second crest at middle - -	.0065
Length of a tooth of second crest -	.0020 "

[This specimen is missing from the collection.]

Sagenodus paucicristatus Cope. Plate I, Figs. 11*a*, 11*b*.

Ceratodus paucicristatus Cope, 1877, Proc. Am. Phil. Soc., p. 54.

Ptyonodus paucicristatus Cope, 1877, Proc. Am. Phil. Soc., p. 192. (Pal. Bull., No. 26.)

Sagenodus paucicristatus Woodward, 1891, Cat. Foss. Fishes Brit. Mus., Pt. II, p. 261.

Sagenodus paucicristatus Williston, 1899, Kans. Univ. Quart., Series A, p. 175.

"The single tooth representing this species is narrow in the transverse direction, but stout in vertical diameter. But four ridges are present, all of which have a single direction, but the shorter ones are the less oblique to the long axis of the tooth. They all extend into the inner border but become low as they approach it. Distally they are quite prominent, but do not project very far beyond the emarginate border between them. The inner border is plane and vertical, and without ledge; the inferior surface is concave in the transverse direction. The surface of the tooth is minutely and elegantly corrugated."

MEASUREMENTS.

"Length from the base of second rib - - -	.017 m
Depth at base of second rib - - - - -	.0045 "

[No. 6505.]

Peplorhina arctata Cope.

Peplorhina arctata Cope, 1877, Proc. Am. Phil. Soc., p. 55.

Theromorphous Saurian, Proc. Am. Phil. Soc., 1882, footnote to p. 461. (Pal. Bull., No. 35).

The species was based on an imperfect bone bearing small teeth. From its resemblance to the palatal teeth of *Peplorhina anthracina* the author refers it to that genus with the remark that "this course is open to modification should subsequent investigation require it." Later, in 1882, he remarks in a footnote ; "*Peplorhina arctata* Cope from the Illinois Permian is not a *Peplorhina* but a *Theromorphous Saurian*."

The broken specimen originally described certainly has much the appearance of the small teeth which occur in the roof of the mouth of certain of the *Cotylosauria* and may very possibly belong there, but there is present in the collection a complete plate showing no sutural edges. It is certainly a plate from the mouth of a *Crossopterygian* fish, and as the description of the perfect portions of Cope's specimen applies very perfectly to it, it may best be considered under the original name. The applicable portion of the original description is as follows: "The convex surface (of the plate) is thickly studded with teeth, which are not in contact with each other. Their size increases from one side of the bone to the other, and still more, from one extremity to the other. The crowns are swollen at the nearly sessile base, and contract rapidly to a conical and unsymmetrical apex. One side of the latter is slightly concave below the apex. The surface is shiny and distinctly grooved. Fractured crowns do not display any central cavity."

The present specimen is rather oval, one side showing a perfect convex outline and the other with three straight edges at large angles to each other. The whole plate is convex on the toothed side and concave below. The angulated border is thickened and roughened and the rounded border thin. The surface is covered with teeth, larger in the middle and on the thickened border than on the other edges. The plate is .0158^{m} long and .0114^{m} wide.

[Nos. 6511 (Cope's type) and 6512.]

Cricotus heteroclitus. Plate I, Figs. 12*a*, 12*b*, 12*c*, 12*d*, 13, 14.

Cricotus heteroclitus Cope, 1875, Proc. Phil. Acad. Nat. Sc., p. 405.

Cricotus heteroclitus Cope, 1877, Proc. Am. Phil. Soc., p. 64.

Cricotus discophorus Cope, 1877, Proc. Am. Phil. Soc., p. 186. (Pal. Bull., No. 26.)

Cricotus heteroclitus Cope, 1878, Proc. Am. Phil. Soc., p. 522. (Pal. Bull., No. 29.)

The genus was founded on some intercentra which were regarded as centra of the caudal region; it was not until 1878 that the true nature of the intercentra was made out. With the intercentra were a few other bones doubtfully referred to the same genus. That portion of the original description which is applicable to the bones as intercentra is as follows: "The caudal vertebra (intercentrum) best preserved is stout, discoidal in form, and deeper than wide. It resembles in form that of an herbivorous dinosaurian, but differs otherwise. The articular faces are deeply concave, the posterior most strikingly so; and the middle is occupied by a large foramen, whose diameter is about equal to that of the centrum on each side of it. The lateral borders of the posterior articular face are expanded backwards, and articulate with a bevel of the corresponding edge of the anterior articular extremity. In this way the vertebra combines the mechanical relations of the biconcave with opisthocœlian structures. These neural arches (hæmapophyses) are narrow and directed backwards; their bases are firmly coössified with the centrum." . . . . "On the inferior (superior) surface of the centrum (intercentrum) two shallow pits occupy considerable space. . . . ." It will be noticed that the describer had the intercentrum inverted; this fact was later understood by himself and certain drawings corrected. The structure of the skull and other portions of the skeleton of the species are described by Cope in the Proc. Am. Phil. Soc., 1878, p. 523 and figured in the same, 1882, Plate II. The synonymy of *C. heteroclitus* and *C. discophorus* was also recognized by Cope in Proc. Am. Phil. Soc., 1878, p. 523.

[No. 6517 (the type specimen), 6518 (type of *C. discophorus*), 6519, and 6520].

Cricotus gibsoni Cope, Plate I, Figs. 15*a*, 15*b*, 15*c*.

Cricotus gibsoni Cope, 1877, Proc. Am. Phil. Soc., p. 185. (Pal. Bull., No. 26.)

Represented in the collection by several vertebræ, all of one form. Cope considered the type specimen as probably from the caudal region. He says, "On this vertebra there is no trace of diapophysis, and the neurapophysis rises from the external side of the superior face. The wall of the neural canal is not preserved, but the inference is that the diameter of the latter is large. This fact and the absence of definite chevron articulations leads me to doubt the caudal position of the vertebra; but the usual marks of the dorsal and cervical vertebrae are totally wanting from it. As in *C. heteroclitus*, the *foramen chordæ dorsalis* is large, its diameter being one third of the total. The articular faces descend steeply into it, that of one extremity more so than the other. The rim of the latter face is beveled outwards, the plane thus produced appearing on the inferior face something like the united faces of the chevron bones.

"The centrum is a little deeper than wide, and the inferior face is truncate so as to give a subquadrate outline. The inferior plane is concave, the concavity being divided by a longitudinal rib. The sides are somewhat concave, with a longitudinal rib at the middle. Diameters of centrum: vertical .010^m; transverse .009^m; longitudinal .008^m. Width of inferior plane .005^m; width above, including neurapophyses .008^m.

"As compared with *C. heteroclitus* this species differs in the presence of parallel ridges inclosing a median fossa on the inferior side of the centrum. The small size may be considered, but it is uncertain whether the two animals represented by the vertebrae are fully grown."

[Nos. 6521 and 6522.]

Cricotus sp. Plate V, Figs. 13*a*, 13*b*, 14*a*, 14*b*, 15, 16.

There are several phalanges of *Cricotus*. They are much stouter than those of *Clepsydrops;* even in the members of the distal series, where the phalanges are very short, they are still very stout, almost as broad as long. They show a delicate sculpture over the entire surface; the articular surfaces are less well defined than in the reptilian forms. In the middle series they are longer in proportion than at either end, rather curved, flattened, and with the shaft little less in width than the extremities.

[No 6523.]

Diplocaulus salamandroides Cope. Plate I, Figs, 16*a*, 16*b*, 17*a*, 17*b*. Plate V, Figs. 17*a*, 17*b*, 17*c*, 17*d*.

Diplocaulus salamandroides Cope, 1877, Proc. Am. Phil. Soc., p. 187. (Pal. Bull., No. 26.)

Diplocaulus salamandroides Cope, 1882, Proc. Am. Phil. Soc., p. 451. (Pal. Bull., No. 35.)

Cope's generic description is as follows: "Vertebral centra elongate, contracted medially, and perforated by the foramen chordæ dorsalis; coössified with the neural arch, and supporting transverse processes. Two rib articulations one below the other, generally both at the extremities of the processes, but the inferior sometimes sessile. No neural spines nor diapophysis; the zygapophyses normal and well developed."

Specific description: "The surface of the centrum is smooth and is without grooves. The diapophyses and parapophyses are rather elongate, and are closely approximated one above the other. The superior process issues from the centrum opposite the superior margin of the articular faces. They stand equidistant from the extremities of the centrum, and are directed obliquely backwards. The anterior zygapophyses occupy the same level. The neural spine is a compressed longitudinal ridge; it divides behind, leaving a notch between the posterior zygapophyses."

MEASUREMENTS.

" Diameter of centrum	longitudinal	.0060^{m}
	vertical	.0025
	transverse	.0025
Depth of centrum and neural arch		.0060
Width with transverse processes		.0070
Expanse of posterior zygapophyses		.0050 "

A portion of a small skull was in contact with one of the vertebra. The ramus of the jaw is shallow and stout, the external surface sculptured with inosculating lines. Teeth with cylindrical roots set in shallow alveoli. The crowns elongate, slightly compressed near the apex, and without grooves or lines.

In describing the vertebræ of *D. magnicornis* from Texas (Proc. Am. Phil. Soc., 1882, p. 453) Cope calls attention to the presence of zygosphene and zygantrum in that species; they are also present in the *D. salamandroides*, but are so small as to easily escape notice. The surface of the centrum is stated to be smooth in the Illinois species, this is largely due to weathering, as the more perfect specimens show the same beautiful sculpture as in the Texas forms, The articulations for the ribs are separate in the cervical region, and become more and more closely united posteriorly. The resemblance between *D. salamandroides* and *D. magnicornis* is very striking, almost the only observable difference being in the size, the latter being from five to six times the size of the former. This statement is limited to the vertebral column, as the skull of the Illinois species is unknown.

In the Proceedings of the Am. Phil. Soc., 1882, p. 452 (Pal. Bull., No. 35), Cope gives a history of the classification of *Diplocaulus* and a summary of the characters of the genus as derived from specimens from the Permian of Texas.

[Nos. 6513, 6514, 6515, and 6516.]

Clepsydrops colletii Cope. Plate II, Figs. 1*a*, 1*b*, 1*c*, 2*a*, 2*b*, 3*a*, 3*b*.
Clepsydrops colletii Cope, 1875, Proc. Phil. Acad. Sc., p. 407.
Clepsydrops colletii Cope, 1877, Proc. Am. Phil. Soc., p. 62.

This genus was based on a series of vertebræ supposed to represent the cervical caudal and dorsal regions. With them were associated other bones, which in all probability did not belong to the same specimen, though they may have belonged to the same species of the genus. The vertebræ were compared with those of the *Cricotus*, or rather with the intercentra of *Cricotus*, as Cope was not entirely sure at the time of the amphibian nature of *Cricotus*. The original description of the vertebræ given by Cope to characterize the genus *Clepsydrops* is as follows: "They are deeply biconcave, the articular cavities being funnel-shaped and continuous, thus perforating the entire length of the centrum. In a dorsal vertebra the cavities communicate by a very small orifice, while in the posterior the median contraction of the canal is less marked. The posterior cavity is more gradually contracted than the anterior; in the latter the excavation is, in most of the vertebræ, but slight (except beneath the floor of the neural arch), until it falls rather abruptly into the axial perforation. In an (?) anterior dorsal it is as widely excavated at the border as the posterior funnel. Another peculiarity is the absence of the processes of the centrum; and a small capitular articulation is seen sessile on the border of the cup of two of the dorsals.

"The axis has a singular form, owing to the tubular perforation which continues the posterior excavation to the anterior face of the centrum. There are three articular faces, a larger subround inferior and two smaller superior, which border the neural canal in front and below and are separated from each other and the inferior face by the perforation in question. The anterior face slopes obliquely backwards and downwards, and is convex in transverse section. There is no facet for the free hypapophysis of the odontoid, but it appears that the inferior articular face was applied exclusively to the centrum of the atlas, as in *Sphenodon*. But the axis differs from that of the latter genus in the abscence of a coössified odontoid process. Either that element is entirely wanting or it consists of two pieces, interrupted in the middle by the notochordal foramen, and in correspondence with superior articular facets. There is no true hypapophysis of the axis, and the only indication of lateral processes is a small articular facet on each side on the lower part of the rim of the posterior funnel. These may have been related to rudimental cervical ribs. The neural arch is broken off.

The dorsal vertebræ have their sides somewhat contracted; in one specimen the inferior face is rounded, in another, which I suppose to belong to a different part of the column, it is longitudinally acute. In this and another dorsal, where the parts are exposed, the floor of the neural canal is interrupted by a deep fissure, which has a triangular shape with apex downward when seen in profile. This is due to the fact that the opposite halves of the centrum are united by the circumferences of the articular cups, which have in profile an X shape. The diapophysis does not project far beyond the base of the neural arch and is compressed. The caudals are elongate, and resemble, in the forms of the centrum and neural arch, those of *Lælaps.* The neural spines are not preserved, but if present were directed well backwards, bearing the posterior zygapophyses, since the arch stands only on the anterior three-fifths of the centrum. Chevron facets are not distinct, but two emarginations on the rim of the posterior face of one of the vertebræ indicate their existence. In other centra even these notches are wanting. The tail was evidently tapering. There is no evidence of the transverse fissures seen in *Sphenodon* and many *Lacertilia,* nor are there any diapophyses on the caudal vertebræ preserved.

Specific characters: "There is a shallow fossa in the entering angle between the superior and inferior articular facets of the front of the axis, and the centrum of the same is obtusely keeled below. The border of the anterior face of the dorsal vertebræ with keeled centrum is undulate. The obtuse inferior face of another dorsal is rugulose, and the edge of the face is not undulate. The inferior faces of the two caudals are marked with fine parallel grooves, while in another caudal and the (?) sacrals the same is smooth. There are some longitudinal ridges on the upper side of the larger caudal."

MEASUREMENTS.

"Length of centrum of axis - - - - - -	.006^{m}
Width do. at middle behind - - - - -	.008
Depth do. (oblique) - - - - - - -	.010
Length centrum of sharp keeled dorsal - -	.014
Depth do. behind - - - - - - - - -	.012
Width do. behind - - - - - - - -	.012
Length centrum rounded dorsal - - - -	.012
Depth do. behind - - - - - - - -	.011
Width do. behind - - - - - - -	.010
Width neural canal do. - - - - - -	.004

Length centrum larger caudal	.014$^{\mathrm{m}}$
Width do.	.008
Depth do.	.008
Length smaller caudal	.010
Depth centrum do.	.007
Width do.	.007 "

[Nos. 6530 (type specimen), 6531, and 6578.]

Clepsydrops pedunculatus Cope. Plate II, Figs. 4*a*, 4*b*, 4*c*, 4*d;* Figs. 5*a*, 5*b*, 5*c*, 5*d*.

Clepsydrops pedunculatus Cope, 1877, Proc. Am. Phil. Soc., p. 63.

This genus was established on two vertebræ, a third cervical, and an anterior caudal, regarded by Cope as a dorsal.

"Both differ from corresponding vertebræ of *C. colletti* and *C. lateralis* (this is evidently a slip on the part of the describer; there is no *C. lateralis; C. vinslovii* is evidently referred to, as it was the only other species of the genus described at this date) in having elongate diapophyses for the attachment of the ribs. These are present in the other species, but are either very short, or sessile. The third cervical has a broad reverted anterior lip-like margin of the anterior articular face, which resembles the corresponding part in *C. lateralis* (*vinslovii*) in not being produced below. The median line is keeled, and there is a shallow longitudinal groove on the upper part of the sides. The posterior articular face is regularly funnel shaped. The diapophyses are very stout, and are directed a little downwards and strongly backwards. The articular faces are single, look downwards and outwards, and are wide above, and narrow below. The base of the neural canal is deeply incised, as in the other species."

MEASUREMENTS.

" Diameter of centrum	antero-posterior	.015 $^{\mathrm{m}}$
	transverse	.0125
	vertical	.012
Length of diapophysis above		.009
Diameter of diapophysis	vertical	.008
	antero-posterior	.005 "

In the description of the supposed dorsal attention is called to the long and slender diapophysis; it is evident that this is not a diapophysis, but an anchylosed rib with the distal broken portion inclined forward, as is characteristic of the anterior caudal ribs of the *Rhyncocephalia.* Speaking of other portions of the vertebra, the describer says: "There is no recurved rim of the articular extremities, but the surface does not pass regularly into the foramen chordæ dorsalis, but by an abrupt descent at its mouth. The sides of the centrum are concave, and the inferior portion forms a prominent rounded rib."

MEASUREMENTS.

" Diameter of centrum	antero-posterior	.016^{m}
	transverse	.015
	vertical	.016 "

[Nos. 6534 (type specimen) and 6535.]

Clepsydrops vinslovii Cope. Plate II, Figs. *7a*, *7b*, *7c*, *7d*.
Clepsydrops vinslovii Cope, 1877, Proc. Am. Phil. Soc., p. 62.

This species was based on a single cervical vertebra with which others were uncertainly identified. The specific characters given are as follows: "The inferior median line is a keel; some distance above it, the sides of the centrum are full, rising in a longitudinal angle. There is no constriction or fossa below the diapophysis as in *C. colletti*. The latter is anterior in position, is vertically compressed, and is curved forward for a short distance below. The posterior articular face is regularly funnel-shaped from the margin; the anterior face has a broad recurved lip. This passes around the inferior margin, which is not projected forwards as in *C. colletti*. The zygapophyses are well developed, and stand close together. The neural spine is compressed, and the basal portion points somewhat forwards."

MEASUREMENTS.

" Length of centrum		.011^{m}
Diameter of posterior articular face	vertical	.009
	transverse	.009
Vertical diameter of diapophysis		.006
Expanse of posterior zygapophysis		.009
Antero-posterior diameter of base of neural spine		.005
Transverse diameter of neural arch		.006 "

[Nos. 6532 (type specimen) and 6533.]

Lysorophus tricarinatus Cope. Plate II, Figs. 12*a*, 12*b*, 12*c*.
Lysorophus tricarinatus Cope, 1877, Proc. Am. Phil. Soc., p. 187. (Pal. Bull., No. 26.)

The type specimens consist of two vertebræ and a portion of a third. The generic characters given by Cope are as follows: "Vertebræ amphicœlian, perforated by the foramen chordæ dorsalis. Neural arch freely articulated to the centrum. Floor of neural canal deeply excavated. No processes or costal articulations on the centrum, which is excavated by longitudinal fossæ. Centrum not shortened." Specific characters: "Two centra and a portion of a third represent this species. The former are a little longer than wide and a little depressed. The facet for the neural arch is an elongate plane truncating the border of the fossa of the neural canal on each side, for one half to three fifths the length of the centrum. Two deep longitudinal fossæ extend on each side of a median rib of the inferior face; and they are separated above by a narrower rib from another longitudinal fossa which is below the base of the neural arch.

MEASUREMENTS.

" Diameter of centrum	longitudinal	.0055^{m}
	vertical	.0038
	transverse	.0040
Length of facet for neurapophysis		.0035
Width of neural canal		.0020 "

This form differs very decidedly from any other in the collection in the prominence of the keel and the lateral ridges; they, or rather the fossæ between them, are developed to an extent that almost destroys the centrum, leaving but a very slender tube surrounding the notochord. A few centra of larger size show strongly developed keels and free neural arches, but much stouter proportions.

[Nos. 6526 (the type specimen; it is badly broken), 6527, and 6528.]

Archæobelus vellicatus Cope. Plate III, Fig. 1.

"*Species No. 4*" Cope, 1877, Proc. Am. Phil. Soc., p. 56.

Archæobelus vellicatus Cope, 1877, Proc. Am. Phil. Soc., p. 192. (Pal. Bull., No. 26.)

This genus is represented by teeth alone. In his discussion of the form Cope says, in the earlier paper, "there is nothing to prevent their (the teeth) reference to the *Lacertilia*." The generic description is as follows: "The form is conical, and the surface is not grooved nor furnished with prominent ridges. The interior is hollow, and the walls are composed of a few concentric layers without external enamel or cementum. The solid base to which it is attached is shallow, presenting smooth surface on the opposite side, which is deeply impressed by a longitudinal groove at one end." The specific description is given in the earlier paper: "The crown is conic, subround in section, and curved backward. There are no cutting edges, and the base is a little flattened in front and behind. On each of the faces thus formed, there is an open, shallow groove, sometimes obsolete. There are no other grooves or sculpture on the teeth. . . . . One of the specimens displays an extensive pulp cavity."

MEASUREMENTS.

	First specimen	First specimen	Second specimen
" Diameter of base	.004^{m} long	.008^{m} short	.005^{m}
		First specimen	Second specimen
Length of crown		.010^{m}	.015^{m} "

There are several specimens of the isolated teeth described by Cope in the collection, but in addition a considerable portion of a maxillary bone which shows many points of interest. In all the single teeth, as described by Cope, they are attached to a portion of the jaw and unaccompanied by any other teeth, but there is posterior to the tooth a cavity which, as shown by the more perfect jaw, accommodated a second tooth larger even than the first. In the fragment of the jaw there are, first, three quite small teeth, and then, supported by a swollen portion of the rim, there are two very large canine teeth ; posterior to these, three teeth about equal in size to those anterior to the canines, and then five smaller ones. As both ends of the piece are incomplete, it is certain that there were more teeth than here recorded. Several differences from *Clepsydrops* and *Dimetrodon* are apparent: first, the anchylosis of the teeth to the jaw, instead of being inserted in well defined alveoli; second, the presence of two enlarged canines instead of one, and third, the possible absence of the diastema anterior to the canines; for in the *Dimetrodon* the anterior teeth of the maxillary decrease to small size immediately and the notch of the diastema begins just anterior to the canine and below the external nares, but here, though the anterior tooth is almost below the nares, there is no sign of the beginning of the notch, if any existed. The teeth are all more or less rounded in section and show no sign of a cutting edge. In general appearance the jaw is much like that of the Pelycosaurians; *i. e.*, with a thin outer wall and a heavy shelf-like dentigerous edge.

Associated with the fragments of the upper jaws are several portions of the lower jaws showing the symphasial region. Some of the anterior teeth, about the third and fourth, seem to have been slightly larger than the others, but as such a small part is preserved it is impossible to say definitely. These fragments may have belonged to the genus *Clepsydrops*, and, indeed, the fragments of the upper jaws also.

[Nos. 6524 and 6525.]

UNNAMED SPECIMENS.

Besides the specimens named and described by Cope there are present in the collection many isolated bones from different parts of the skeleton which cannot be identified with certainty as belonging to any of the forms described; that they belong to some of them is practically certain. The fact that the bones are nearly always found isolated and generally in a fragmentary condition prevents any attempt at a restoration of the skeleton, but their resemblance to corresponding bones from the Texas deposits makes it probable that the animals from the two regions did not differ materially in form. One fact is noticeable, the absence of animals of any great size as compared with the Texas forms.

Skull.—The skull is represented by two nearly perfect maxillaries, apparently the bones from the two sides of the same specimen, and several fragments showing the occipital condyles.

The premaxillaries are similar to those of *Dimetrodon* and of *Empedias* as figured by Cope. The external surface is pitted, and there was evidently a large opening of the external nares. The teeth do not show any great disparity in size nor are they chisel-shaped; there is no evidence of the presence of a diastema as in the *Pelycosauria* in general, but this may be due to the imperfection of the bone. Plate III, Figs. 2, *a* and *b*. [No. 6536.]

The occipital condyles are well rounded, hemispherical in outline, the upper edge being slightly concave, and marked by a pit near the upper edge. [No. 6537.]

Vertebræ.—There are a great many vertebræ, either isolated specimens or small lots belonging together; the majority evidently belong to one or the other of the three species of *Clepsydrops* described. There are two lots that seem different from the others.

Two vertebræ very much larger than the others apparently belong to the lumbar or posterior dorsal region. They are characterized by the breadth of the centrum as compared by its height. The lower surface is marked by a rounded but prominent keel. One shows measurements corresponding very closely with those given by Cope for *C. natalis* from Texas. It is very possible that they represent this species. [No. 6538.]

A second set of vertebræ resemble in large measure those of *Lysorhophus tricarinatus* in the free articulation of the neural arch to the centrum and the general form of the centrum; they differ, however, in the absence of the strongly marked keels and the deeply incised fossæ between them. They vary greatly in size, some being as large as those of *L. tricarinatus* and others three or four times as large. If it were not for the presence of vertebræ of different size they might be regarded as dorsals of the described species. As it is, they seem to indicate a possible new species.

MEASUREMENTS.

"Length of a centrum	$.011^{m}$
Breadth of a centrum	.011
Length of a second centrum	.007
Breadth of a second centrum	.006 "

Plate II, Fig. 13, *a*, *b*, and *c*. [No. 6529.]

Scapula.—There are many incomplete scapulæ in the collection. They are all of small size, but resemble in form those figured by Cope (Proc. Am.

Phil. Soc., Aug. 1884, and Proc. Am. Assoc. and Sc., 1884, Vol. XXXIII) and Case (Trans. Am. Phil. Soc., 1899, Vol. XX.) One specimen shows the proximal end with articular cavity for the humerus formed by the scapula and coracoid. The scapula is perforated by a foramen just above the articular face. Plate III, Fig. 3. [No. 6540.]

Humeri.—There are four types of humerus. One, the largest, is relatively much shorter and stouter than the others, and is remarkable for the strong articular faces and the generally robust character. The proximal end is marked by prominent rugosities and the deltoid crest is laterally expanded, much more so than in the other forms, and very rough. Length .14^{m}; width of the head at the deltoid ridge .057^{m}. Plate III, Fig. 4, *a*, *b*. [No. 6541.

The second form has a much longer shaft than the first, and at all points shows a greater elegance of form at the expense of strength, but the extremities are as well formed and the articulate surfaces as distinct. This probably belongs to one of the described forms of *Clepsydrops* from Illinois, probably the largest, *C. pedunculatus*. A smaller form of the same type is represented by the distal end of another humerus, which is perfectly preserved. The entepicondylar foramen is large and elongate, the ectepicondylar foramen is represented by a notch, as in all the *Pelycosauria;* the head for the proximal end of the radius is prominent, almost hemispherical and well formed, it is continuous with the articular surface for the ulna. Height of fragment .066^{m}, width at deltoid ridge .030^{m}. Plate III, Fig. 5, *a*, *b*, *c*, and Fig. 6. [Nos. 6542, 6543, and 6575.]

The third type is represented by the distal end of a very small form similar in many respects to the foregoing, but with the internal process rounded and truncated and the entepicondylar foramen missing. The form is very small and the shaft of the bone was slender, but the distal extremity shows a strong development. The process forming the ectepicondylar notch is prominent, and the portion of the distal extremity on either side of the articular surface extended below the surface instead of lying in a line with it or not reaching so far. This form may be the same as the "No. 6" mentioned by Cope in his first contribution to the fauna of the Texas Permian, but as it was not described nor figured, it is impossible to say definitely. The humerus "No. 6" is regared by Cope as belonging to a possibly fossorial animal, this may be true of the present form, but there is no vertabræ in the collection which could go with such a type. Plate III, Fig. 7. [No. 6544.]

The fourth and last type differs very considerably from the others. The ends are concave, as if they had been cartilaginous in life, and there are no articular surfaces distinguished. The extremities are at right angles to each other, and there is a small deltoid process, continuous with the proximal end. The entepicondylar foramen is present, but there is no trace of an ectepicondylar notch. Length .038^m, width proximal end .0105^m, distal end .0205^m. Plate III, Fig. 8, *a, b, c, d.* [No. 6545.]

Ulnæ.—There are two types of ulna distinguished by the size only. One is nearly as large as the ulna of *Dimetrodon incisivus* and quite similar to it; the proximal end only is preserved; the other is smaller, represented by the proximal end also, and probably belongs to one of the smaller species of *Clepsydrops.* Plate III, Fig. 9. [Nos. 6546 and 6547.]

Femoræ.—The femora are mostly of the same type, but show considerable variation in size. They all have the distal articular surfaces upon the inner or lower face of the distal end, showing that the leg was habitually flexed and the animal progressed, probably, with the belly on or near the ground, in the manner of the alligator. One of the medium sized forms is figured (No. 6548). Length of one specimen, .077^m; a larger specimen, .107^m. Plate IV, Fig. 1, *a* and *b.* [Nos. 6548, 6549, 6550, 6551, 6552, and 6553.]

The distal ends of two very small femora are present; they lack well-developed articular surfaces, though the contour of the extremity is the same as in the larger specimens. It seems probable that they are immature forms. [No. 6552.]

Tibia.—There is one complete tibia, somewhat crushed, and the proximal end of another. The whole bone is larger at the proximal than at the distal extremity, and is considerably curved. The shaft is more or less flattened. The proximal end has two faces, which are distinct, or nearly so; they are oblong and lie with their long axes nearly at right angles to each other. The anterior extremity of one anticular face forms the upper portion of the cnemial crest. Measurements: length, .049^m. Plate IV, Fig. 2, *a* and *b.* [No. 6555.]

Fibula.—What appears to be a fibula is .053^m long. It is a slender bone, expanded at the extremities and quite strongly curved. Plate IV, Fig. 3. [No. 6554.]

Ilia.—There are two types of ilia of about the same size. Each presents two articular faces at the distal portion for articulation with the ischium and pubis and a rather deeper articular portion of the acetabulum; at the upper portion of the acetabulum there is a prominent overhanging process. The two forms differ principally in the anterior process of the ilium with which it is attached to the sacral vertebræ. In one form it extends almost straight forward (No. 6556) and in the other (No. 6557) it is curved and the anterior end is somewhat lower than the posterior. The inner side of each presents strong longitudinal ridges and there does not seem to be any articular facet for the vertebræ. In an incomplete fragment, in which the ischium and ilium are in contact, the acetabulum is seen to be quite deep. Plate IV, Figs. 4 and 5. [Nos. 6556, 6557, and 6558.]

Footbones.—There is a large series of footbones, the position of most of which it is impossible to determine. They are all well formed, with good articular surfaces, showing that the carpus and tarsus was fairly strong and well knit. Some of the more common bones of indefinite position are shown in Plate V, Figs. 18, *a* and *b;* 19, *a* and *b;* 20, *a* and *b.* [No. 6559.]

Astragali.—There seem to be two forms of astragalus. The first is much the more slender and smaller. There are two distinct facets for articulation with the calcaneum ; the upper of these is the largest and is separated from the lower by a notch which, in combination with a similar notch separating the two articular faces on the calcaneum, forms a foramen between the bones. On the opposite side of the bone there is a large face set at an angle with the body of the bone, apparently for the tibia. The lower rim of the bone between the described regions has a narrow face for the bones of the tarsus. This ilium was ascribed by Cope to *clepsydrops colletii.* The form of the bone is shown in Plate IV, Fig. 7, *a, b, c, d.* [No. 6560.]

The second type is of stouter proportions than the first and larger; the articular faces are arranged much the same, but are broader and the face for the distal end of the tibia is more sharply divided into faces meeting at a considerable angle. Plate IV, Fig. 8, *a* and *b.* [No. 6561.]

Neither of these forms corresponds with the figure of the astragalus of *Clepsydrops leptocephalus,* published by Cope (Proc. Am. Phil. Soc., Aug. 1884; Am. Assoc. Ad. Sc. Vol. XXXIII, 1884), nor to an astragalus of *Pariotichus incisivus* in the collection of the Walker Museum.

The strong angulation of the tibial face is described by Cope as belonging to the genus *Dimetrodon,* so that it is possible that the larger astragalus in the Illinois material may represent that genus.

Calcanea.—The calcanea are of the type characteristic of most of the Permian reptiles from America. Large, subround disks of no great thickness ; the side toward the astragalus presents two facets separated by a notch ; above and below are facets for the fibula (?) and the tarsal bones. Plate IV, Fig. 9, *a* and *b.* [No. 6562.]

Metacarpals and Tarsals.—The metacarpals and tarsals are long and slender, with well developed articular faces. Plate V, Figs. 1 and 2. [No. 6563.]

Phalanges.—The phalanges show the same well developed form as the preceding row, even to the terminal series. The terminal series are slender, pointed, and curved, and evidently supported strong claws. Plate V, Figs. 3–9, and 10, *a* and *b.* [Nos. 6564 and 6565.]

Among the specimens that cannot be referred with certainty to any form are the following:

Teeth.—There are several isolated teeth or portions of jaws with teeth attached, which cannot be assigned to any of the described forms. It is probable that if more complete material were at hand they would be found to belong to forms already described, either from Illinois or Texas.

"*Species one*" Cope, 1877, Proc. Am. Phil. Soc., p. 56.

This is an incomplete maxillary with six broken teeth. "They stand in close juxtaposition and are of equal size. The basal half or more of the crown displays the character of deep inflections or grooves. These teeth belong to some sauroid fish or batrachian." Plate V, Fig. 12. [No. 6566.]

"*Species two*" Cope, 1877, Proc. Am. Phil. Soc., p. 56.

A fragment of a mandibular ramus with four teeth. "The anterior of these is larger and is separated from the others by an edentulous space. Their crowns are rather elongate and are compressed, having cutting edges fore and aft. Both edges contract to the apex, but the anterior the more so. There are a few shallow grooves at the base, but they appear to be superficial only." As remarked by Cope, it is impossible to tell whether they belong to an amphibian or a reptile. Plate V, Fig. 11. [No. 6567.]

"*Species three*" Cope, 1877, Proc. Am. Phil. Soc., p. 56.

"Two stout, slightly flattened, conic teeth, without cutting edges, represent this species. They are anchylosed to a very thin plate of bone, a part of which adheres to each. The base is oblique, expanding more in one direction than in another. The greater part of the crown is marked by closely placed parallel grooves, which are more numerous than in the species No. 1. They are larger than those of No. 2, measuring .004^{m} in diameter at the base. They may belong to any one of a number of known genera of batrachia or sauroid fishes." [No. 6568.]

Besides these, there are two teeth that seem to indicate forms not otherwise represented in the collection. The first is rather conical and recurved, the upper end truncate, but the inner side shows a concave region of wear against the opposed tooth. This would seem to show that it is either an incisor or one of the lateral teeth, probably the first, of some member of the *Diadectidæ*. Plate V, Fig. 23, *a* and *b*. [No. 6569.]

The second is a very stout, conical tooth, much larger than any other in the collection. Its surface is marked with deep, irregularly arranged grooves. Plate V, Fig. 24. [No. 6570.]

A lower jaw, nearly complete, resembles very closely that of *Pariotichus* from Texas. The articular region is complete and shows a well formed face and a prominent spur extending posterior to the cotylus. Fragments of other jaws show the same feature. The outer side is marked by strong reticulate sculpture, which at the posterior part seems to radiate from a point on the lower margin about an inch from the posterior end; on the anterior portions the lines are straighter and lie parallel to the length of the jaw. The teeth were very small. A small fragment attached to the inner side of it is covered with many minute teeth; this may be a portion of the dentition of the upper jaw. [No. 6571.]

A collection of fragments showing a fine sculpture on one side are probably portions of the skull of *Diplocaulus*. Among these are imperfect plates with a much coarser sculpture, which are probably abdominal scales. [No. 6572.]

There are two pubes nearly complete; they may belong to *Cricotus*. There is a considerable portion of the acetabular face present. This portion of the bone is thickened, and besides supporting the acetabular face has a broad face for the ilium. Just below these faces the bone is perforated by a foramen. Beneath the foramen is the symphasial region, which is remarkably broad and thick in proportion to the rest of the bone. In general the outline of the bone was subround, but the lower posterior portion was very thin, and portions have been broken away in both specimens. On the upper margin, posterior to the facet for the ilium, there is a slender tubercle which bears an articular facet; in one specimen this is isolated and in the other it is confluent with a broad facet on the thickened posterior border. Plate IV. Figs. 6, *a* and *b*. [No. 6573.]

There are a few coprolites of small size. They show spiral markings ndicative of a spiral vale in the stomach of the form to which they belonged. [No. 6574.]

EXPLANATION OF PLATES.

PLATE I.

FIG. 1. *Janassa linguæformis.* Twice nat. size. *a*) from below, *b*) from above, *c*) from the side.

FIG. 2. *Janassa gurleyna.* Twice nat. size. *a*) from below, *b*) from above, *c*) from the side.

FIG. 3. *Pleuracanthus quadraseriatus.* *a*) from the side, *b*) from the front.

FIG. 4. *P. gracilis.*

FIG. 5. *P. compressus.* *a, b, c,* and *d.*

FIG. 6. *Sagenodus vinslovii.* *a*) from below, *b*) from above.

FIG. 7. *S. vabasensis.*

FIG. 8. *S. gurleyanus.* *a*) from below, *b*) from above, *c*) from the side.

FIG. 9. *S. pusillus.* *a*) from below, *b*) from above.

FIG. 10. *S. fossatus.* *a*) from below, *b*) from above.

FIG. 11. *S. paucicristatus.* *a*) from below, *b*) from above.

FIG. 12. *Cricotus heteroclitus.* Intercentrum. *a*) from above, *b*) from before, *c*) from the side, *d*) from below.

FIG. 13. *C. heteroclitus.* Intercentrum.

FIG. 14. *C. heteroclitus.* Intercentrum.

FIG. 15. *C. gibsonii.* Intercentrum.

FIG. 16. *Diplocaulus salamandroides* Dorsal vertebra. *a*) from the side, *b*) from below. Twice nat. size.

FIG. 17. *D. salamandroides.* Dorsal vertebra. *a*) from above, *b*) from below. Twice nat. size.

PLATE II.

FIG. 1. *Clepsydrops colletii.* Dorsal vertebra. *a*) anterior, *b*) lateral, *c*) posterior.

FIG. 2. *C. colletii.* Dorsal vertebra. *a*) lateral, *b*) inferior.

FIG. 3. *C. colletii.* Dorsal vertebra. *a*) lateral, *b*) showing vertebra divided on median line.

FIG. 4. (*?*) *C. colletii.* *a*) inferior, *b*) lateral, *c*) anterior, *d*) posterior.

FIG. 5. *C. pedunculatus.* Anterior caudal. *a*) lateral, *b*) anterior, *c*) posterior, *d*) inferior.

FIG. 6. *C. sp.* Dorsal vertebra. *a*) lateral, *b*) posterior, *c*) anterior.

FIG. 7. *C. vinslovii.* Dorsal vertebræ. *a*) lateral, *b*) posterior, *c*) anterior, *d*) inferior.

FIG. 8. *C. sp.* Caudal vertebra. *a*) lateral, *b*) anterior, *c*) inferior, *d*) posterior.

FIG. 9. *C. sp.* Caudal vertebra. *a*) lateral, *b*) inferior.

FIG. 10. *C. sp.* Caudal verebra, lateral.

FIG. 11. *C. sp.* Axis. *a*) anterior, *b*) lateral, *c*) inferior.

FIG. 12. *Lysorhophus tricarinatus.* Dorsal (?) vertebræ. *a*) from the side, *b*) from above, *c*) from below.

FIG. 13. *L. sp.* Dorsal (?) vertebræ. *a*) from above, *b*) from the side, *c*) from below.

PLATE III.

FIG. 1. *Archeobolus vellicatus.* Maxillary.

FIG. 2. Premaxillary. *a*) from before, *b*) from the side.

FIG. 3. Scapula and Coracoid.

FIG. 4. Humerus. × ½. *a*) lateral view, *b*) posterior view.

FIG. 5. Humerus. *a*) anterior, *b*) proximal end, *c*) lateral, half nat. size.

FIG. 6. Humerus. Distal end of same form as 5.

FIG. 7. Humerus. Distal end.

FIG. 8. Humerus. *a*) anterior view, *b*) lateral, *c*) and *d*) outlines of the proximal and distal faces in natural position.

FIG. 9. Proximal end of Ulna.

PLATE IV.

FIG. 1. Femur. *a*) anterior, *b*) posterior.

FIG. 2. Tibia. *a*) proximal end, *b*) anterior view.

FIG. 3. Fibula.

FIG. 4. Ilium.

FIG. 5. Another type of ilium.

FIG. 6. Pubis. *a*) inner view, *b*) outer view.

FIG. 7. Astragalus of *Clepsydrops sp.* *a*) tibial face, *b*) anterior (?) face, *c*) calcaneal face, *d*) posterior (?) face.

FIG. 8. Astragalus of *Clepsydrops sp.* *a*) anterior (?) face, *b*) posterior (?) face.

FIG. 9. Calcaneum. *b*) astragalus face.

PLATE V.

FIGS. 1 and 2. Metacarpals of *Clepsydrops.*

FIGS. 3–9. Phalanges of *Clepsydrops.*

FIG. 10. Terminal phalanx of *C.* *a*) lateral, *b*) superior views.

FIG. 11. "Species one."

FIG. 12. "Species two."

FIG. 13. Phalanges of *Cricotus.* *a*) lateral, *b*) anterior views.

FIG. 14. Phalanges of *Cricotus.* *a*) anterior, *b*) lateral views.

FIGS. 15 and 16. Phalanges of *Cricotus.*

FIG. 17. *Diplocaulus salamandroides.* Dorsal vertebra. *a*) lateral, *b*) superior, *c*) terminal, *d*) inferior views.

FIGS 18–21. Carpal bones.

FIG. 22. Proximal end of a rib

FIG. 23. Incisor tooth. *a*) anterior view, *b*) lateral

FIG. 24. Tooth.

E. C. CASE.

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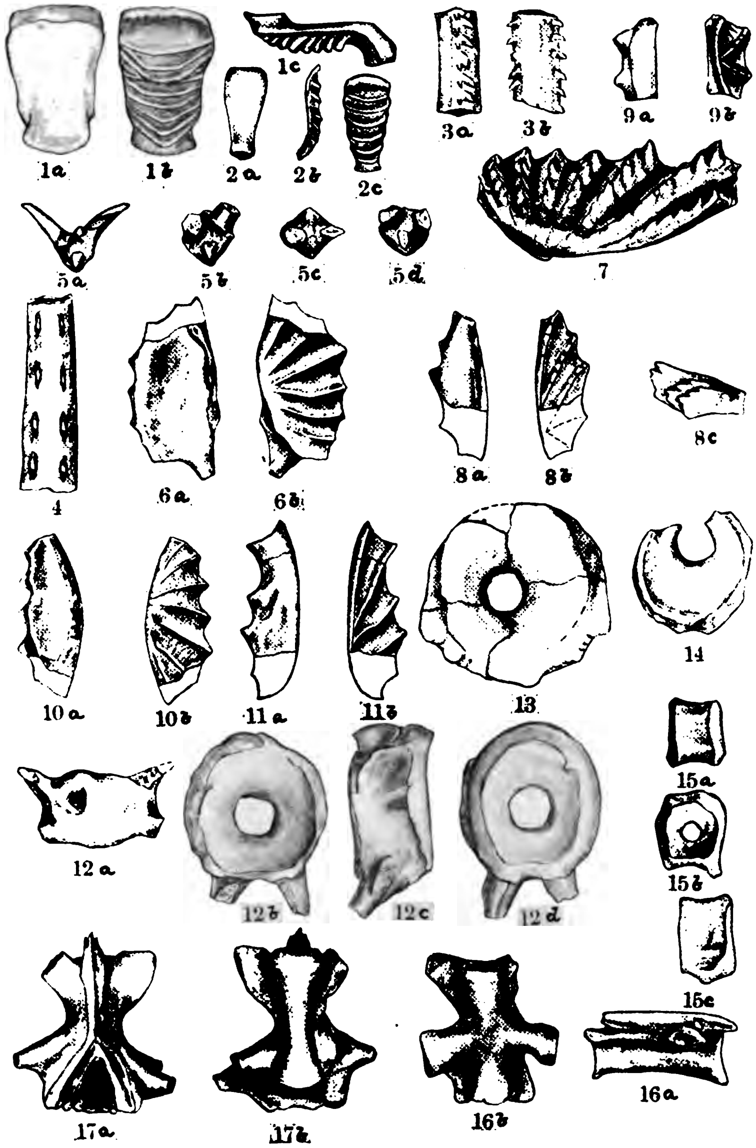
Milwaukee, Wis.

PLATE I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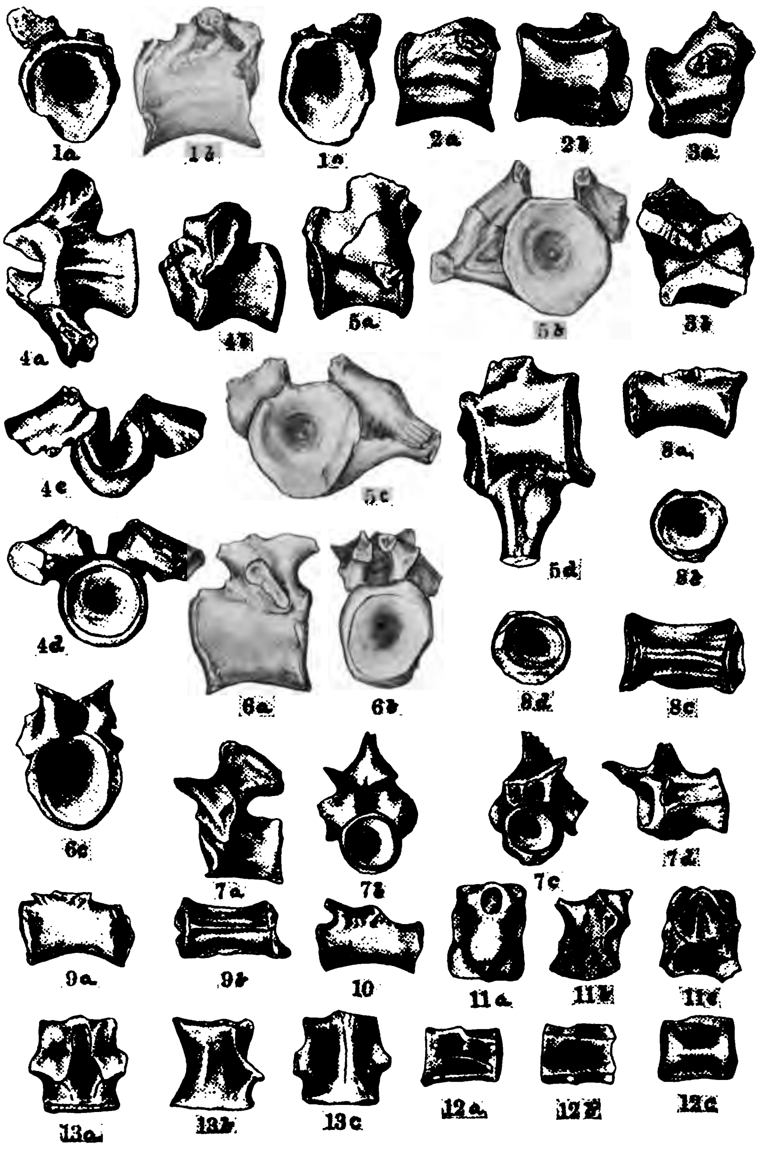
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